

**RCRA/ACT 64 OPERATING
LICENSE RENEWAL APPLICATION**

FORD

**FORD MOTOR COMPANY
ALLEN PARK CLAY MINE LANDFILL
ALLEN PARK, MICHIGAN**

**VOLUME IV
SUPPLEMENTAL INFORMATION**

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REPORT ON
CONSTRUCTION QUALITY ASSURANCE MONITORING SERVICES
CELL 2
ALLEN PARK CLAY MINE
FORD MOTOR COMPANY
ALLEN PARK, MICHIGAN

~~Volume I of II~~
COMBINED INTO ONE VOLUME

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Ford Motor Company
15201 Century Drive, Suite 602
Dearborn, Michigan 48120

Attention: Mr. Jeffrey L. Hartlund, P.E.

**RE: CONSTRUCTION QUALITY ASSURANCE MONITORING SERVICES
CELL 2 - ALLEN PARK CLAY MINE
ALLEN PARK, MICHIGAN**


Dear Mr. Hartlund:

This report describes the construction quality assurance (CQA) monitoring and testing services provided by Golder Construction Services, Inc. (GCS) during the development of Cell 2 at the Allen Park Clay Mine. The CQA monitoring and testing services were performed by GCS on this project through January 27, 1993 indicated that construction of Cell 2 was carried out in substantial compliance with the design, specifications, and facility Permit issued by the Michigan Department of Natural Resources as described in the attached report.

We appreciate the opportunity to work with you and Ford Motor Company on this project and look forward to future opportunities to assist you. If you have any questions, comments or need additional assistance, please contact us.

Very truly yours,

GOLDER CONSTRUCTION SERVICES, INC.



David M. List, P.E.
Senior Engineer

DML/JEW:laa

ABSTRACT

Golder Construction Services, Inc. (GCS) previously called Environmental Construction Services, Inc. (ECS) was retained by the Ford Motor Company in May of 1990 to perform third party construction quality assurance (CQA) monitoring and testing services during the development of Phase I, Cell 2 at their Allen Park Clay Mine Landfill (APCML) facility. The APCML facility is located within Wayne County at 17005 North Oakwood Boulevard in Allen Park, Michigan. The APCML facility covers an area of approximately 243 acres and is designed and permitted for both solid and hazardous waste disposal. The site is occupied by an operating solid waste landfill unit and several closed solid and hazardous waste landfill units.

Within the lining system of Cell 2 there are seven major components. Each component covers the entire floor and side slopes of the landfill. The individual components are listed as follows from the bottom to top:

- Cell Base Floor
- Artesian Water Collection/Removal System (AWCRS)
- Secondary Flexible Membrane Liner (FML)
- Secondary Leachate Collection/Removal System (LCRS)
- Five Foot Recomacted Clay Layer (RCL)
- Primary Flexible Membrane Liner (FML)
- Primary Leachate Collection/Removal System (LCRS)

The following is a list of construction areas which GCS monitored:

- Construction of the stabilization berms and final grading of the cell floor;
- Installation of the artesian water collection/removal system;
- Installation of the secondary flexible membrane liner;
- Installation of the secondary leachate collection system;
- Construction of a five foot thick recomacted clay layer;
- Installation of the primary flexible membrane liner;
- Installation of the leachate collection/removal system; and
- Installation of electrical and mechanical components of the leachate collection system.

GCS' on-site involvement with the project began on May 15, 1990 and field work was completed January 28, 1993. During active periods of construction, GCS provided full time CQA monitoring services for both the soils and geosynthetics aspects of this project.

The results of the monitoring and testing confirm that Phase I, Cell 2 was constructed in substantial compliance with the project specifications and guideline documents.

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1.0 INTRODUCTION

Ford Motor Company (Ford) owns the Allen Park Clay Mine Landfill (APCML) facility located in Wayne County at 17005 North Oakwood Boulevard in Allen Park. The facility is located within the city limits of Allen Park and is bounded by Oakwood Boulevard, Interstate 94, Outer Drive, and M-39 (Southfield Freeway). The APCML facility consists of approximately 243 acres and is designed and permitted for both solid and hazardous waste disposal. The site is occupied by an operating solid waste landfill unit and several closed solid and hazardous waste landfill units. The general location of the site is shown on Figure 1.

Ford is currently permitted to construct Cell 2 at the APCML facility. While the construction of Cell 2, including excavation and early backfilling to the general cell floor grades, has been ongoing for several years, the landfill lining system construction has occurred since 1990. This report discusses the results of the construction quality assurance (CQA) monitoring and testing services provided by Golder Construction Services, Inc. (GCS) during the development of the hazardous waste landfill cell known as Cell 2 - Phase I (hereafter referred to as Cell 2). A future vertical expansion into Phase II of the Cell 2 unit is planned.

2.0 SCOPE OF SERVICES

Golder Construction Services, Inc. (GCS) under contract with Ford, provided CQA monitoring and testing services at the APCML facility associated with the development of Cell 2. The following is a list of construction areas which GCS monitored:

- Construction of the stabilization berms and final grading of the cell floor;
- Installation of the artesian water collection/removal system;
- Installation of the secondary geomembrane liner;
- Installation of the secondary leachate collection system (leak detection system);
- Construction of a five foot thick recompacted clay layer;
- Installation of the primary geomembrane liner;
- Installation of the primary leachate collection/removal system; and
- Installation of electrical and mechanical components of the leachate collection system.

As stated, monitoring and testing services extended into each of the above mentioned areas and are discussed herein. Cell 2 has an "L" shaped configuration measuring approximately 800 feet long and 600 feet wide at the widest point. A layout of the facility showing Cell 2 is presented on Figure 2.

This report presents a description of the CQA monitoring and testing services provided by GCS and its subconsultants throughout the construction process. Discussion of the project participants and the project specifications is presented in Sections 3.0 and 4.0, respectively. Material testing, which includes both soils and geosynthetics used in the construction, is presented in Section 5.0. Discussion of construction and CQA monitoring and testing activities is presented in Sections 6.0 and 7.0. Survey control procedures are discussed in Section 8.0, and a summary is included in Section 9.0.

It should be noted that construction quality assurance and quality control are often denoted by the acronyms "QA" and "QC", respectively, and "CQA/CQC" collectively. Throughout this report, the abbreviation "CQA" is used to collectively refer to all QA activities performed by GCS, to refer to the CQA procedures as discussed further in Section 4.0, and within the titles of GCS personnel. Also, "geosynthetic" is an industry term which collectively refers to geomembrane liner, geotextile and geonet materials. This term, as well as the individual component terms, is used throughout the remainder of this report.

3.0 PROJECT PARTICIPANTS

3.1 Overview

The following lists the principal project participants with their respective roles in the construction of the landfill:

- Ford Motor Company (Ford) - Facility owner;
- Michigan Department of Natural Resources (MDNR) - Regulatory enforcement agency;
- NTH Consultants Ltd. (NTH) - Co-design engineer;
- Midwestern Consulting, Inc. (MCI) - Co-design engineer and construction surveyors;
- McNamee, Porter & Seeley, Inc. (MPS) - Construction manager and third party surveyor;
- McNamee Industrial Services (MIS) - Electrical and mechanical design review engineer;
- Newport Electrical Company (NEC) - Electrical contractor;
- Golder Construction Services, Inc. (GCS) - Construction quality assurance consultant and geosynthetic testing laboratory;
- B&V Construction, Inc. (B&V) - Earthworks contractor;
- Mike Wilson Enterprises (MWE) - HDPE pipe installer and mechanical contractor;
- National Seal Company (NSC) - Geosynthetic installation contractor and geomembrane liner material manufacturer;
- T.J. Crawford, Inc. (Crawford) - Borehole contractor for pipeline;
- Golder Associates, Inc. (Golder Associates) - Soil testing laboratory (as a subconsultant to GCS);
- Lowe Construction Company (Lowe) - Sheet pile contractor;
- Amoco Fabrics and Fibers Company (Amoco) - Geotextile supplier;
- Conwed Plastics, Inc. (Conwed) - Geonet supplier;

- London Sand and Gravel Company - Clay and granular material supplier;

In addition to those listed, there were several other minor project participants involved in supplying materials and/or services to this project which have not been listed herein. It should be noted that the abbreviated form of the companies, as listed in parentheses above, are used throughout the remainder of this report. Generally, only the principal project participants will be referenced. Subconsultants participation will be implicitly included with the name of the appropriate principal participant.

It should be noted that Golder Construction Services, Inc. (GCS) was previously named Environmental Construction Services, Inc. (ECS). A formal name change to GCS took place on April 1, 1992. For the purpose of this report, when referring to CQA monitoring and testing services on this project, GCS will be used.

3.2 GCS Personnel

GCS on-site involvement with the project began on May 15, 1990. Due to construction intensity, rotations, and occasionally expanding hours into a night shift, the resident CQA staff during earthwork activities varied from a single lead CQA manager up to two additional earthworks monitors. The site personnel were directed by a GCS project CQA manager who is a registered Professional Engineer in the State of Michigan. During the installation of the geosynthetic components of Cell 2, up to four additional geosynthetic monitors were added to the on-site staff. As stated above, a lead CQA manager was resident on-site and was responsible for managing the day-to-day CQA activities associated with the construction. The CQA monitors were responsible for the CQA observation, testing, and documentation of the activities associated with the construction. A listing of the GCS personnel and initials of those directly involved in this project is provided in Appendix A.

Each CQA monitor was responsible for completing a daily report summarizing the monitoring activities performed. The lead CQA manager prepared a summary of the daily construction progress, including the information provided by each of the CQA monitors and the field test results. Copies of these daily reports are not presented in this document, but are retained on the project site and in the East Lansing, Michigan office of GCS.

For completeness and as a guide to the initials used in the appendices, a listing of the NSC personnel involved with the installation of the geosynthetic components of this project is also included in Appendix A.

4.0 CONSTRUCTION DOCUMENTS

The Allen Park Clay Mine facility was designed by NTH and MCI, who also prepared several CQA, specification, and design documents employed on this project. The documents pertinent to the construction of Cell 2 include the following:

- Allen Park Clay Mine Landfill, Hazardous Waste Disposal Site -Cell II, City of Allen Park, Wayne County, Michigan (18 page design drawing set dated October 1, 1991);
- United States Environmental Protection Agency, Region V, EPA ID # MID 980-568-711, permit effective from June 8, 1989 to June 8, 1994;
- Michigan Department of Natural Resources, Act 64, Operating License ID Number 980-568-711, effective from May 8, 1989 to May 8, 1994;
- Specification NO. APCML91-5, Type I Hazardous Waste Cell Construction, Allen Park Clay Mine, Allen Park, Michigan, MID 980568711, Section D, revised March 18, 1992;
- Contract Documents Cell II Procurement and Installation of Geosynthetics, Hazardous Waste Cell II Construction, Allen Park Clay Mine, Allen Park, Michigan, dated April 28, 1992; and
- Clay Liner Test Pad Construction Study, Allen Park Clay Mine, NTH Project No. 89365 OW, dated January 7, 1991, revised April 19, 1991.

These documents were reviewed by GCS prior to construction at the facility.

Any clarifications of, and revisions to, these documents which were made throughout the construction process are presented in Appendix B. In this report, reference to the landfill construction drawings, CQA plan and technical specifications will implicitly include the clarifications and revisions detailed in the memoranda formally documented throughout the construction process. These cumulative requirements with all addenda are referred to throughout this report as the project "Specifications".

5.0 MATERIAL TESTING

5.1 Introduction

An assortment of soil and geosynthetic materials were used within the lining system of Cell 2. Per the project Specifications, these materials were tested both in advance of construction and as construction proceeded. This section describes the testing carried out on the various materials used, prior to use.

5.2 Compatibility/Fingerprint Testing

During the late 1980's, Ford retained geotechnical consultants to identify soil and geosynthetic materials with physical and mechanical properties meeting those required by the project Specifications. These materials were then analyzed for chemical compatibility by exposing them to leachate for various time periods and re-evaluating the properties. The following materials underwent compatibility testing: clay, sand, gravel, piping, and geosynthetics. The results of this testing were submitted to the Michigan Department of Natural Resources (MDNR) in previous reports by others. As a result of the compatibility testing, certain soil materials and specific pipe and geosynthetic products were found to be useable in the construction of Cell 2.

Prior to the construction of Cell 2, samples of the soil materials and the specific pipe and geosynthetic products targeted for use were obtained. The samples were then evaluated and compared to those found to be useable by previous testing. The soil materials underwent geotechnical testing in a soils laboratory, which is discussed in later sections of this report, and were determined to be suitable for use. The pipe and geosynthetic products were sent to Geosyntec Consultants' Materials Testing Laboratory (Geosyntec) for evaluation. The results of this testing are presented in Appendix C. In summary of Geosyntec's evaluation, tests indicate that the new geosynthetics are generally equivalent to their respective archive samples.

5.3 Soil Testing

Prior to the construction of Cell 2, extensive testing was carried out on the clay, sand, and gravels targeted for use. Samples of these soils were obtained from borrow sources and as the materials were delivered to the site, but prior to use in the landfill. A test pad study was also

conducted on the clay materials targeted for use. The following sections discuss the testing which occurred prior to the materials use in the landfill.

5.3.1 Clay Borrow Source

An investigation into the available clay sources was conducted by NTH. Three sources were identified and bulk samples were collected from each for laboratory testing. This laboratory testing was used to determine the suitability of the soils being investigated and to provide reference information for the placement of the soil components in the landfill. Samples were obtained from potential sources and the following tests were performed on each sample:

- Atterberg Limit determination
- natural moisture content determination
- soil classification determination
- grain size distribution analysis
- moisture-density relationship (modified Proctor)
- hydraulic conductivity analysis

The results of the testing indicate that the following three sources of material met the requirements set forth by the design.

- Borrow from Interstate 696 (I-696 Clay)
- Borrow from London Sand and Gravel Company, London, Michigan (London Clay)
- Borrow from Ann Arbor Sand and Gravel Company, Ann Arbor, Michigan (Ann Arbor Clay)

A summary of the results of the testing performed on the clay materials used is presented in Appendix D.1.

5.3.2 Test Pad Program

Following the identification of suitable clay borrow sources, a test pad program was undertaken by NTH. The purpose of the program was to determine if the clay sources could meet/exceed the project hydraulic conductivity criterion of less than or equal to 1×10^{-7} centimeters per second (cm/s) and to establish the soil moisture-density conditions required to meet this criterion. The clay sources that were identified during this investigation and chosen for use were the I-696

Clay, the London Clay, and the Ann Arbor Clay. A test pad was constructed from material taken from each source.

The construction monitoring of the test pad program was performed by NTH. Each test pad was built to a thickness of approximately 3 feet over an area approximately 75 feet by 150 feet. Following the construction of each test pad, nine Boutwell permeameters were installed which totaled 27 permeameter locations for the program. Additionally, undisturbed samples were taken from the test pads for laboratory hydraulic conductivity testing, grain size distribution analysis, Atterberg Limits determination, moisture content, unit weight determination, and selective testing of unconfined compressive strength. A report, entitled "Clay Liner Test Pad Construction Study, Allen Park Clay Mine Landfill, NTH Project No. 89365 OW, revised and reissued April 19, 1991" discusses in detail and presents all the findings of the study. This report is presented in Appendix E. The results of the test pad program indicate that the clay sources targeted for use demonstrate a hydraulic conductivity less than or equal to 1×10^{-7} cm/s when placed at a specified moisture content and compactive effort.

5.3.3 Clay On-Site Sampling

The clay identified in the borrow source investigation and used during the test pad program was delivered to the site for use within Cell 2. GCS obtained samples of this clay on an ongoing basis as it was stockpiled and used.

Of the approximately 130,000 cubic yards of clay fill used in construction, thirty-four samples were obtained resulting in an approximate sampling frequency of one test per 3,800 cubic yards. Samples were shipped to a Golder Associates soils laboratory and tested for the following parameters:

- Atterberg Limit determination
- natural moisture content determination
- soil classification determination
- grain size distribution analysis
- moisture-density relationship (modified Proctor)

Three of the thirty-four samples tested did not undergo grain size distribution analysis and two of those did not undergo Atterberg Limit determination. A summary of these test results is presented in Appendix D.1. Five additional sample results from NTH were included since they were referenced during on-site testing.

5.3.4 Granular Material

The coarse aggregate or gravel as it is hereafter referred to, used within the artesian water collection/removal system (AWCRS) and the leachate collection/removal system (LCRS) was supplied by Manchester Sand and Gravel Company from their Parr road location in Manchester, Michigan. Of the approximately 300 cubic yards of gravel used with the AWCRS and the LCRS, 2 samples were obtained for laboratory analysis. One sample underwent grain size analysis, soil classification, and hydraulic conductivity testing, while the second sample was analyzed for grain size distribution. The results of this testing are presented in Appendix D.2.1 and indicate that the material used conforms with the project Specifications and Michigan Department of Transportation (MDOT) Class 6A stone.

5.3.5 Sand

The granular drainage material or sand as it is hereafter referred to, used within the LCRS was supplied by Milford Sand and Gravel from their Kent Lake Road location in South Lyon, Michigan. Of the approximately 4,600 cubic yards of sand used, 3 samples were obtained for laboratory analysis. Two of these samples underwent grain size analysis, soil classification and hydraulic conductivity testing. The remaining sample was tested only for hydraulic conductivity. The results of this testing are presented in Appendix D.2.2 and indicate that the material used conforms with the project Specifications and MDOT Class 2NS sand.

5.4 Geosynthetics

5.4.1 Geomembrane Liner

Smooth 80-mil thick high density polyethylene (HDPE) geomembrane liner was used within the secondary and primary landfill lining system. The HDPE geomembrane was manufactured and installed by NSC in 15-foot wide rolls. GCS inventoried the geomembrane rolls as they were delivered to site. A summary of this inventory is presented in Appendix F.1. The following sections outline the resin and roll manufacturers' testing program and GCS' conformance testing program prior to use within Cell 2.

5.4.1.1 Resin Testing

Quality control testing of the HDPE resin used to manufacture the geomembrane and the extrusion rod was performed by the resin supplier, Union Carbide Chemicals. Each resin batch was tested for density and melt flow index prior to shipment to NSC's manufacturing plant in Galesburg, Illinois. The test results provided by the resin manufacturer were reviewed by GCS and are included in Appendix F.2.

Quality assurance testing of the HDPE resin was performed by NSC. Samples of the resin were obtained upon delivery to NSC's facility. Resin batches were tested for density and melt flow index. Copies of the results of this testing as provided by NSC were reviewed by GCS and are also included in Appendix F.3.

5.4.1.2 Roll Testing

Thirty-nine rolls of HDPE geomembrane liner supplied for this project were sampled and underwent quality control testing by NSC in the manufacturing facility. The testing program conducted by NSC results in a frequency of approximately one sample per 32,000 square feet of HDPE geomembrane delivered. Each sample tested was evaluated for density, thickness, tensile characteristics (stress at yield, elongation at yield, stress at break, and elongation at break), carbon black content and dispersion, dimensional stability, puncture resistance, tear resistance, density, melt flow index, water absorption, hardness, volatile loss, environmental stress crack resistance, hydrostatic resistance, and modulus of elasticity.

During GCS' review of the project Specifications and actual test results, two items were specifically noted. The first is that a typographical error concerning the acceptable geomembrane hardness value occurred within the project Specifications. NTH was notified and has discussed this clarification in a letter presented in Appendix B. The second item is in regard to the specific gravity obtained during some testing. The results of the testing indicate that while some material exhibits a specific gravity slightly higher than the project requirements, it meets the intent of the project Specifications.

The certificates documenting the roll quality control testing of the HDPE geomembrane liner rolls delivered are included in Appendix F.4. A review of these reported test results was performed by GCS. Any samples found not to meet project Specifications, except as discussed above, were bound by passing results and either retested or rejected. In either case, rolls ultimately failing to meet project Specifications were rejected from use.

GCS also performed testing on the geomembrane liner rolls after they had been delivered to the project site. Samples measuring at least 3 feet wide by the width of the HDPE geomembrane roll were obtained at least 3 feet into the roll by GCS site personnel. The samples were then transported to the GCS laboratory located in Duluth, Georgia for testing.

Geomembrane rolls delivered to the site were tested as prescribed by ASTM D4354 in that a specified number of samples from each lot or batch were obtained for laboratory testing. Throughout the duration of the project, approximately 1,252,500 square feet of HDPE geomembrane was delivered to the site for use. From the geomembrane delivered, a total of 24 samples were obtained and tested. Samples were collected from every resin batch and shipment delivered. These samples were tested for the same properties as stated for quality control testing. The resulting sampling frequency is approximately one per 52,200 square feet of material delivered. In certain cases, tested samples failed to meet project requirements. These samples would then be bound by rolls exhibiting passing results and either retested or rejected. The results of the HDPE geomembrane roll testing performed by GCS are summarized in Appendix F.5.

5.4.2 Geonet

A HDPE geosynthetic drainage net, hereafter referred to as geonet, was utilized on this project. Layers of the geonet are located above the geotextile in the AWCRS, above the secondary HDPE geomembrane in the leak detection system, and above the primary HDPE geomembrane within the LCRS. The geonet used on this project, product name XB8410, was manufactured by Conwed Plastics, Inc. in 6.5-foot wide rolls. GCS site personnel inventoried the geonet as it was delivered to the site. A summary of this inventory is presented in Appendix G.1.

The geonet rolls supplied for this project underwent quality control testing at a frequency of one per 40,000 square feet by Conwed in the manufacturing facility. Certification statements from Conwed regarding the quality control testing are included in Appendix G.2.

In addition to manufacturer's testing, GCS also performed testing on the geonet rolls provided for this project. Samples measuring at least 3 feet wide by the width of the roll of geonet were obtained at least 3 feet into the roll by GCS personnel at the Allen Park Clay Mine. The samples were then transported to the GCS laboratory located in Duluth, Georgia for testing.

Geonet rolls delivered to the site were tested as prescribed by ASTM D4354 in that a specified number of samples from each lot or batch were obtained for laboratory testing. Throughout the duration of the project, approximately 1,445,730 square feet of HDPE geonet was delivered to the site for project use. From the geonet delivered, a total of twenty-eight samples of material were obtained. These samples were then tested for the melt index, specific gravity, wide strip tensile strength (machine direction and cross direction) and transmissivity. The resulting sampling frequency is approximately one per 52,000 square feet which exceeds project requirements.

GCS evaluated the geonet test results as the project was ongoing. Very early in the project it was determined that the Conwed product could not consistently meet the project Specifications for wide strip tensile strength or transmissivity in the cross direction. Ford considered alternate geonet products, however, early compatibility tests indicate that the Conwed geonet performed

favorably when exposed to leachate. Upon closer review by NTH, a specification modification was implemented for the geonet properties in the cross machine direction. This modification is presented in Appendix B.

Upon review of laboratory test results, one roll of geonet did not meet project requirements. This sample was bound by rolls exhibiting passing results and was rejected. The results of the testing are summarized in Appendix G.3.

5.4.3 Geotextile

A non-woven 8 ounce per square yard geotextile is located directly over the cell base floor within the AWCRS, above the geonet within the SLCRS and within the LCRS. The geotextile was manufactured by Amoco Fabrics and Fiber Company and was installed by NSC. GCS inventoried the geotextile rolls as they were delivered to the project. A summary of the geotextile inventory is presented in Appendix H.1.

Of the 1,980,000 square feet of geotextile supplied for this project twenty samples underwent quality control testing by Amoco at their manufacturing facility. Each sample was evaluated for weight, thickness, tensile characteristics (grab stress at yield, grab elongation), mullen burst, puncture resistance, trapezoidal tear, permittivity, and apparent opening size. GCS has reviewed the results of this testing and found them to meet or exceed the project Specifications. The certificates documenting the quality control testing of the geotextile rolls delivered are included in Appendix H.2.

In addition to the manufacturer's testing, GCS also performed testing on the geotextile rolls provided for this project. Samples measuring at least 3 feet wide by the width of the roll of geotextile were obtained at least 3 feet into the roll by GCS personnel at the Allen Park Clay Mine. The samples were transported to the GCS laboratory located in Duluth, Georgia for testing.

Geotextile rolls delivered to the site were tested as prescribed by ASTM D4354 in that a specified number of samples from each lot or batch were obtained for laboratory testing. Geotextile rolls produced on non-consecutive dates were identified as separate batches. Throughout the duration of the project approximately 1,980,000 square feet of geotextile from five different batches were delivered to the site for project use. From the geotextile delivered, a total of twenty-five samples of material were obtained by GCS and tested for the specified properties. The resulting sampling frequency is approximately one per 79,000 square feet for the geotextile. Geotextile rolls failing to meet project requirements were bound by rolls exhibiting passing results. Failing or untested rolls between the bounding passing rolls were not used within Cell 2. The results of the testing and the related project Specifications are summarized in Appendix H.3.

6.0 CONSTRUCTION

6.1 Overview

As discussed previously, Cell 2 is designed for hazardous waste disposal. The plan area of Cell 2 is approximately 11 acres with the approximate dimensions of 600 feet by 800 feet. The floor of the cell is approximately 2.5 acres in area and is sloped at greater than 1 percent toward a centrally located sump. From the floor, the side slopes rise at a slope of two horizontal to one vertical (2H:1V) to the crest of the stabilization berms which surround the floor. The crest of the stabilization berm slopes gently and varies from approximately 85 feet wide on the north slope, 70 feet wide on the west and south slopes, to 50 feet wide on the east slope. The north, west and south slopes rise from the bench at a four horizontal to one vertical (4H:1V), to the crest of Phase I. An anchor trench exists for geosynthetics at the outside of the Phase I bench. The east slope rises at three horizontal to one vertical (3H:1V). The east slope is graded to match the previous Cell I closure.

Within the lining system of Cell 2 there are seven major components. The configuration of some of the components vary slightly between the cell floor and the slopes. The individual components across the floor, listed from the bottom up, are as follows:

- Cell Base Floor;
- Artesian Water Collection/Removal System (AWCRS) - comprised of four inch diameter HDPE piping, gravel, geotextile, and geonet;
- Secondary Geomembrane Liner;
- Secondary Leachate Collection/Removal System (SLCRS or Leak Detection System) - comprised of geonet and geotextile;
- Five foot thick Recompacted Clay Layer;
- Primary Geomembrane Liner; and
- Leachate Collection/Removal System (LCRS) - comprised of 6 and 8 inch diameter HDPE piping, gravel, a sand blanket, and geotextile.

The individual components across the slope vary only slightly from the floor as follows: the AWCRS is comprised of geotextile and geonet and the LCRS is comprised of geonet and geotextile.

The details associated with the construction, CQA monitoring and testing performed by GCS for each of these major components of the lining system within Cell 2 are described in the following sections. Throughout this report, all references to dimensions used are the nominal values unless otherwise specified.

6.2 Cell Base

The cell base of the landfill provides the bottom layer and foundation and consists predominantly of both in situ and recompacted native clay materials. Preliminary preparation of the cell base floor occurred prior to GCS' involvement with the project. Certification of the base floor preparation of Cell 2 was provided by others. A letter report containing this information is provided in Appendix I.

Additional preparation of the cell base, including localized filling and final grading of the cell base floor, construction of the stabilization berm, and construction of some of the sideslope area, was required prior to the installation of the AWCRS and subsequent components of the lining system. GCS monitored this additional work.

6.2.1 Excavation

The construction operations to develop the cell base floor elevations consisted of excavation of in situ materials to or below the design grades. The earthwork operations were conducted by conventional equipment, primarily dozers, scrapers, backhoes, articulating dump trucks, and motor graders. After the cell base floor elevations were obtained, the cell was proofrolled with a Superpac D3B roller. Any soft or unsuitable areas encountered were excavated and filled with clay fill, compacted, and proofrolled again. After proofrolling, MPS conducted a survey of the floor surface.

6.2.2 Materials

During the backfilling of excavated areas and construction of the stabilization berms, I-696 Clay, London Clay or native clay was used as backfill. The clay fill material was sampled prior to use from the stockpile areas by GCS to determine acceptability and provide reference information for

construction monitoring. Bulk soil samples were laboratory tested as discussed in Section 5 of this report.

6.2.3 Construction Procedures

Clay fill was transported from the stockpiles to the landfill with scrapers or articulating dump trucks. The material was then spread and leveled with a dozer, moistened with water as necessary to prevent drying, cracking, and to increase adhesion of layers, and compacted using a penetrating foot compactor. The placement of fill was in nominally 6-inch thick compacted lifts to reach the required grade. Typically a minimum of 6 to 8 or more passes with the compactors were applied prior to placement of the next lift. Typically, upon completion of a lift, the surface was scarified prior to placement of a subsequent lift.

6.2.4 Field Testing

Field density and shear tests were performed by GCS as the fill was placed and compacted. The field density testing was performed using nuclear methods ASTM D 2922 and D3017 with drive cylinder tests performed routinely adjacent to the nuclear test to verify the results of the nuclear densimeter. In addition, GCS performed one-point moisture density (Proctor) tests as necessary to confirm the choice of reference curves used. Per the project Specifications, the minimum percent compaction allowable was 90 percent of the modified Proctor's maximum dry density as determined by ASTM test procedure D1557. Soil shear strengths were also measured routinely using either a Torvane or vane shear testing device. Per project Specifications, the minimum shear strength allowable was 1,500 pounds per square foot (psf). Areas with test results failing to meet project Specifications were rejected and identified for repair. Subsequently, such areas were corrected through one or more of the following:

- addition of water and mixing;
- scarification and drying;
- application of additional compactive effort;
- removal and replacement.

Following corrective measures the areas were retested. The repair and testing procedure was repeated until results met or exceeded the project Specifications.

A total of 492 density tests were performed by GCS on the fill placed and compacted in the cell base of Cell 2. Forty-two of these initial tests failed to meet the project Specifications and the corresponding areas were reworked and retested. The results of these tests are summarized in Appendix J.1.

In addition to the field density testing, Shelby tube samples were collected for hydraulic conductivity testing. The results of these hydraulic conductivity tests are presented in Appendix J.2. As shown within the appendix, the results are less than 1×10^{-7} cm/s.

6.3 Artesian Water Collection/Removal System (AWCRS)

The AWCRS was installed directly over the cell base floor and is intended to remove ground water which may collect against the Cell 2 lining system. The AWCRS consists of a geotextile and geonet filter system which discharges to a series of perforated four inch diameter HDPE pipes encapsulated within gravel and geotextile. The geotextile and geonet was installed by NSC while the encapsulated pipes, gravel and other components that comprise the system were installed by various contractors which included B&V, MWE, Lowe, and Crawford.

The AWCRS was constructed in stages as follows:

- Excavation within the cell base floor for the intermediate AWCRS sump and intermediate SLCRS sump;
- Construction of a pit supported by sheet piles within the south stabilization berm;
- Installation of the removal AWCRS sump and removal SLCRS sump in the sheeted pit;
- Installation of boreholes from the toe of the south stabilization berm to the pit and from the pit to the edge of the cell;
- Trenching of the cell base floor and the perimeter of the intermediate collection sumps;

- Installation of the AWCRS pipelines and SLCRS pipeline, AWCRS slope riser pipe and SLCRS slope riser pipe;
- Backfilling of trenches; and
- Installation of geotextile and geonet.

An overview discussion of the construction related to the AWCRS follows.

The floor of Cell 2 is graded toward the centrally located intermediate AWCRS sump and the intermediate SLCRS sump. These sumps are located on the floor of Cell 2 and serve as a collection point for fluids in the AWCRS and leachate in the SLCRS. Fluids then drain from the intermediate collection sumps to the removal sumps through HDPE transmission pipes.

Since the intermediate AWCRS surrounds the perimeter of the intermediate SLCRS sump and is located at a higher elevation than the secondary leachate transmission pipe, the SLCRS sump was excavated and a secondary leachate transmission pipe installed prior to the placement of the AWCRS piping around the intermediate SLCRS sump. Native clay removed from the collection sump excavation was stockpiled outside the cell.

Once the installation of the intermediate collection sumps was completed, the transmission pipelines were installed to the removal sumps within a pit in the south stabilization berm. Both the AWCRS sump and the SLCRS sump are located approximately 22 feet below the top of the south stabilization berm. To install the removal sumps, a pit was excavated within the confines of driven sheet piles. Crawford constructed the pit by first assembling steel sheet piles and vibrating the sheeting to a depth approximately 8.5 feet below the final base level of the sumps. The sheeted pit measured approximately 12.5 feet north to south and approximately 25.3 feet east to west.

Once the steel sheet piles were in place, excavation of the native clay within the sheeted pit was performed with a backhoe. For every 5 feet of excavated clay removed from the sheeted pit, steel whalers were installed for bracing in the longitudinal direction. After approximately 15 feet of

clay had been excavated by the backhoe, a crane with a clamshell bucket was used to complete the excavation. All excavated clay was transported by B&V and stockpiled.

The AWCERS and SLCERS sumps were then installed by MWE. The sumps are located within the sheeted pit and consist of the following:

- a 7 foot diameter and 10 inch thick concrete sump base;
- a 4 foot diameter HDPE sump;
- a 6 foot diameter concrete manhole with openings for the slope risers and transmission pipes; and
- a 7 foot diameter by 8.5 inch thick concrete sump top.

After the 7 foot concrete base was leveled into place on a sand bed, the 4 foot diameter HDPE sump was installed within the pit. The 6 foot diameter concrete manhole was then placed around the HDPE sump, and the connections to the AWCERS slope riser and transmission line were made. Prior to the placement of the 7 foot diameter concrete sump top, a grout consisting of cement and flyash was poured between the 4 foot diameter HDPE sump and the concrete manhole. The concrete sump top was then placed over the concrete manhole so that the excavation could be grouted closed. From the base of the pit to approximately 5 feet below the top elevation of the pit, grout was again used to seal the excavation. The uppermost 5 feet of the steel sheet piles were then removed and the excavation was backfilled and compacted with native clay.

To remove fluids from the sumps, slope riser pipes and transmission pipes are located between the south edge of Cell 2 and the pit, and between the intermediate collection sumps and the pit, respectively. Since both sets of pipes are approximately 10 feet below the cell base floor, Lowe installed boreholes as an alternative to trenching and shoring the excavation. The first set of boreholes were made for both AWCERS and SLCERS riser pipes and extended between the south edge of Cell 2 and the sheeted pit. The AWCERS and the SLCERS slope riser boreholes were 30 inches in diameter and approximately 57 feet long. As the boring process proceeded, a steel casing was advanced to reinforce the sides of the boreholes. Where the boreholes met the sheeted pit, Lowe cut through the sheet piles and advanced the casing to meet the sumps.

The second set of boreholes was made for both AWCRS and SLCRS transmission lines and extended between the toe of the south stabilization berm and the sheeted pit. These boreholes were 20 inches in diameter and approximately 52 feet long. Again, Lowe used steel casings to support the sides of the boreholes and cut the sheet piles to advance the casings into the sheeted pit.

After piercing the pit with the cased boreholes, the riser pipe was installed to the lateral limit of the landfill. The AWCRS riser pipe and the SLCRS riser pipe consisted of a solid wall HDPE SDR 11 pipe, 18 inches in diameter with 1/2 inch perforations at the bottom two feet of the pipe. The 18 inch diameter slope riser pipes were installed by excavating a pipe trench on the south slope of the cell to the 30 inch diameter steel casings. Where the slope riser pipes met the cased boreholes on the south stabilization berm, MWE centered the slope riser pipes in the casing by cribbing the pipe into place. The AWCRS riser pipe and SLCRS riser pipe were then connected to their respective sump with flanged connectors. Finally, the 30 inch diameter casings were grouted and the pipe trench backfilled with native clay.

In addition to the riser pipes, the transmission piping between the removal and intermediate collection sumps were installed after the cased boreholes were installed. Both the AWCRS and the SLCRS transmission lines consist of a solid wall 4 inch diameter HDPE SDR 11 pipe. The AWCRS transmission line extends from the south west corner of the intermediate collection sump and terminates at the removal sump. Both the AWCRS and the SLCRS transmission lines were installed at the same time by excavating a pipe trench from the intermediate collection sumps to the 20 inch diameter steel casings at the toe of the south stabilization berm. The leachate transmission lines were then installed into the casings and centered. Connection to their respective sumps were made by using flanged connectors. After the connections to the sumps were complete, the 20 inch diameter casings were grouted and the pipe trenches were backfilled with native clay.

The AWCRS collection piping system consisted of the following:

- 4 inch diameter perforated HDPE SDR 11 pipe with 2 rows of 1/4 inch diameter holes on 4 inch centers and sixty degrees apart;
- sand for pipe bedding; and
- drainage gravel wrapped in geotextile.

The 4 inch diameter perforated HDPE collection pipes were installed by excavating a trench approximately 2 feet wide by 2 feet deep from the toe of the east and west stabilization berms to the approximate design location of the AWCRS sump. The AWCRS sump piping was then excavated around the sump with a backhoe. After excavating the pipe trench, sand bedding and geotextile were placed into the trench. The 4 inch diameter perforated pipe was positioned on grade into the trench with the 1/4 inch diameter holes positioned 30 degrees from the invert. Drainage gravel was then placed around the collection pipe and the geotextile wrapped completely around the stone. Finally, the geotextile was sewn together using ultraviolet resistant thread.

With the installation of the intermediate and removal sumps and piping system for the AWCRS and SLCRS complete, it was then possible to install the geosynthetics which would cover all the previous construction. The geotextile and geonet filter system is directly above the cell base floor and the side slopes. This system consisted of an 8 ounce per square yard geotextile directly overlying the cell base floor. The geotextile was covered by a geonet. The AWCRS was then bound by the secondary geomembrane liner. As represented in the most recent design package, the geotextile and geonet were to completely cover the north, south, and west slope of the cell, and cover the lower portion of the east slope. On the cell floor, the AWCRS was initially designed to consist of 5 foot wide strips of geonet wrapped with geotextile and spaced at 45 foot centers. The strips were to extend from the north and south stabilization berm toes to the center line of the cell. Instead of using 5 foot wide strips of geotextile and geonet, the floor of the cell was completely covered by geotextile and geonet. All geotextile used in the AWCRS was overlapped a minimum of 4 inches and continuously sewn together using ultraviolet resistant thread. Both the continuous coverage of the geotextile and geonet across the floor and the sewn

4 inch geotextile overlap were viewed as design enhancements. The geonet was also overlapped a minimum of 4 inches and tied into place using nylon ties spaced nominally at 5 foot centers along the slope, 2 foot centers across the slope, and 6 inch centers within the anchor trench.

6.4 Secondary Geomembrane Liner

6.4.1 General

The CQA activities performed by GCS during the installation of the secondary geomembrane liner within Cell 2 consisted of:

- observation and documentation of secondary geomembrane deployment procedures;
- observation and documentation of trial seam procedures and evaluation of test results;
- observation and documentation of field seams and seaming operations;
- location of seam destructive samples, performance of approximately 10 percent of the seam destructive testing, and evaluation of all the destructive testing results;
- observation and documentation of non-destructive seam continuity testing; and
- identification and documentation of defects as well as observation and documentation of repairs.

A detailed description of each of the above activities is presented in the following subsections.

6.4.2 Deployment Procedures and Observations

As required by the project Specifications, the cell base floor subgrade surface was certified and accepted by NSC for placement of the secondary geomembrane liner. Copies of these certifications are included in Appendix K.

Geomembrane panels were deployed manually by pulling them from rolls suspended on a spreader bar attached to a rubber-tired front end loader or deployment cart. Following panel deployment, the panels were aligned with a 5 inch overlap and were seamed using a double track fusion seaming device. Unbounded edges of geomembrane panels were temporarily loaded with sand bags to prevent movement.

Each geomembrane panel was assigned a field identification number by GCS as it was deployed. After the panel was deployed, the edges of the lead, trail, and one side were measured with a micrometer to determine sheet thickness. After placement but prior to seaming, each panel was observed for damage and manufacturing imperfections. Observed defects were marked by GCS and were later repaired by NSC. A summary of the geomembrane panel deployment is included in Appendix L.

Periodically, points along the geomembrane panels were surveyed by MPS in order to locate field panels for development of a record drawing. A plan view of the secondary geomembrane panel layout is shown on Figure 5.

6.4.3 Trial Seam Procedures and Observations

Trial seams were made by NSC from fragment pieces of geomembrane to verify that seaming conditions were adequate. Geomembrane trial seams approximately 10 feet in length were constructed under the same conditions as actual seams, typically three per day; once prior to the beginning of the initial seaming operation, once following the midday break, and at the end of the daily field seaming operations.

For each trial seam, a minimum of four specimens were obtained and tested. The specimens were tested in the peel adhesion (peel) and bonded seam strength (shear) modes. The mode of separation of each specimen tested was classified using the codes shown on Figure 8 for the double track fusion welding technique and Figure 9 for the extrusion welding technique. If a trial seam failed, the seaming apparatus and/or seamer prepared another seam which was retested. Retesting continued until deficiencies were corrected and a passing trial seam was obtained or until the decision was made not to use the particular seaming apparatus and/or seamer during the seaming period.

Each trial seam was assigned a unique number and the pertinent information recorded. A portion of each trial seam was archived by GCS for Ford. A summary of the fusion and extrusion trial

seam information obtained throughout the installation of the secondary geomembrane liner is included in Appendices M.1 and M.2, respectively.

6.4.4 Production Seaming

The principal seaming method used by NSC on this project was the double track fusion technique. This technique was employed for production seaming as the geomembrane panels were deployed. Alternative seaming methods used by NSC on this project were the solid wedge fusion and extrusion techniques. These methods were used primarily to repair defects in the geomembrane liner and perform tie in seams.

The various procedures associated with both fusion and extrusion seaming operations were observed by GCS. These observations included seam preparation, weather conditions during seaming, general seaming procedures, overlap of geomembrane panels, and temporary bonding procedures. All seams were observed throughout their length for quality and seam completion. Visually detected imperfections were marked by GCS and subsequently repaired by NSC. A summary of the geomembrane fusion and extrusion seaming information compiled by GCS is presented in Appendices N.1 and N.2, respectively.

6.4.5 Seam Non-Destructive Continuity Testing

All seam non-destructive continuity testing was performed by NSC to verify completeness and continuity of the seam. Two types of non-destructive testing were employed. Vacuum testing was performed on solid wedge fusion and extrusion welded seams and air pressure testing was performed on double track fusion welded seams. This testing was visually observed by GCS and described in the following sections.

Vacuum testing consisted of applying a soapy solution to the weld area and placing a vacuum box over the segment to be tested. The vacuum box was connected via an air hose to a vacuum pump. When the vacuum box was "seated" properly, the pump would create a suction on the geomembrane. While the vacuum was held, the seam segment was observed through the viewing window for the presence of soap bubbles indicating leakage. If no leakage was found, the next

adjoining area was tested, ensuring that a typical overlap of 3 inches was maintained. If a leak was detected it was marked for repair, repaired, and subsequently retested.

Pressure testing consisted of sealing the ends of the air channel created by a double track fusion seaming device. A needle/pressure gauge was then inserted into the air channel and the air channel was pressurized to at least 25 pounds per square inch (psi). The air channel was allowed to "relax" for a 2 minute interval, after which time the air pressure was noted. If the pressure had fallen below 25 psi, it was again pressurized to at least 25 psi and the pressure noted. The pressure was recorded 5 minutes after the relaxing period ended. If less than 2 psi of pressure was lost during the 5 minute period, the seam end opposite of the pressure gauge was cut. If the pressure gauge reading decreased to zero after the cut was made, the test was successful. If, however, the pressure had dropped more than 2 psi, or if the pressure gauge reading did not decrease to zero upon cutting the opposite end of the seam, the test failed. The process could be repeated in an attempt to isolate the failing area, but in any case, all failing seams or segments were marked for repair, repaired by extrusion seaming, and vacuum tested.

Summaries of the seam continuity testing for the landfill geomembrane fusion and extrusion welded seams are presented with the seaming summaries in Appendices N.1 and N.2, respectively.

6.4.6 Seam Strength Destructive Testing

Seam destructive samples were selected by GCS either randomly or because of a CQA monitor's suspicion of a defective seam. Of the approximately 37,362 linear feet of fusion and approximately 6,750 feet of extrusion seaming and seam reconstruction or capping performed, 86 fusion and 14 extrusion seam destructive samples were obtained. The approximate resulting frequency of destructive testing was one per 434 linear feet of fusion seam and one per 480 linear feet of extrusion seam, which exceed project requirements.

GCS observed as NSC removed all the seam destructive samples from the welded geomembrane liner for testing. In general, two specimens from each destructive sample were first field tested

in peel and shear by NSC using a portable tensiometer. If the field destructive test specimens passed, the remaining portion of the destructive sample was removed from the geomembrane liner installation for laboratory testing. A 12 inch segment was labelled and archived on-site by GCS for Ford and an 18 inch segment was labelled and shipped to the geosynthetic laboratory for testing. Approximately one of every ten samples were tested by GCS' geosynthetic laboratory while nine of ten were tested by NSC' geosynthetic laboratory. During laboratory testing of fusion seams, five specimens were evaluated for peel and five specimens were evaluated for shear. Since both the outside and inside of the weld area were tested for peel, a total of ten peel tests for each seam destructive sample were performed. The acceptance criteria for fusion welded seam specimens was the same as that for the extrusion welded test specimens in that four out of the five specimens must not fail in the weld area. Additionally, project requirements specified that peel adhesion exceed 128 pounds per inch yield strength and those tested for shear exceed 160 pounds per inch yield strength.

For an extrusion seam destructive sample, ten specimens were removed for testing; five specimens were tested for peel and five specimens were tested for shear. The acceptance criteria for peel specimens was that four out of five specimens must not fail in the weld area. Additionally, project requirements specified that peel adhesion must exceed 104 pounds per inch yield strength and those tested for shear exceed 160 pounds per inch yield strength.

Of the 86 initial fusion and 14 initial extrusion destructive samples taken, 15 fusion and 2 extrusion failed to meet project requirements. Each was tracked in both directions as welded and bound by passing destructive samples or completely reconstructed. All failed seam segments were repaired and non-destructively tested. Summaries of the geomembrane fusion and extrusion seam destructive test results are presented in Appendices O.1 and O.2, respectively.

6.4.7 Defects and Repair Observations

Geomembrane panels were initially monitored for damage during deployment. Additionally, GCS observed the geomembrane panels and seams on an on-going basis throughout the installation process. Each observed defect was documented, assigned a unique identification "Defect Code",

marked, and subsequently repaired and vacuum tested by NSC. Repairs made to the geomembrane are summarized in Appendix P.

6.5 Secondary Leachate Collection and Removal System

The SLCRS within the landfill is constructed directly over the secondary liner system. The SLCRS consists of geonet and geotextile across the cell slopes and floor and an intermediate collection sump centrally located on the cell floor. The components of the SLCRS are discussed in the following sections.

6.5.1 SLCRS Sump

An intermediate collection sump is located centrally on the cell floor. As described previously in this report, a transmission pipeline from the intermediate sump location to a removal sump, the removal sump, and the upslope riser for the SLCRS, was installed prior to the installation of the secondary geomembrane. At the intermediate collection sump, the transmission pipeline penetrates the secondary geomembrane and is booted. Within the intermediate collection sump, the transmission line was fitted with a 3.5 foot long section of perforated HDPE pipe forming a tee. The lower portion of the sump surrounding the tee was backfilled with 6A stone. Additionally, five layers of geonet were placed within the sump over the gravel and pipe.

6.5.2 Geonet/Geotextile

The SLCRS across the slopes and floor of Cell 2 was comprised of geonet and geotextile. Following completion of the secondary geomembrane, geonet was deployed by placing panels adjacently along the maximum lines of slope. While a single layer of geonet was used on the cell slopes, a double layer was used across the cell floor. The geonet panels were overlapped a minimum of 4 inches and tied. The tie spacing used was 5 foot centers along the slope, 2 foot centers across the slope, and 6 inch centers in the anchor trench.

An 8 ounce per square yard non-woven geotextile overlies the geonet. The geotextile panels were also placed adjacently generally along the maximum lines of slope. This geotextile was overlapped 4 inches and continuously sewn into place.

6.6 Recompacted Clay Liner

The 5 foot thick recompacted clay liner (RCL) is located directly above the SLCRS. The RCL was constructed by the earthwork contractor, the details of which are described in the following subsections.

6.6.1 Materials

Across the floor and slope of the landfill, the RCL was constructed in nominally 6-inch thick compacted lifts. The lifts were constructed using London Clay and I-696 Clay as discussed in Section 5.

6.6.2 Construction Procedure

The RCL material was transported from the stockpile areas to the landfill using articulated dump trucks and scrapers. To minimize the potential of damage to the underlying geosynthetics, the first 18 inch thick loose lift was placed with a trackhoe. The clay material was spread and leveled with a dozer, moistened with water as necessary, and compacted using a penetrating foot compactor. Typically, the RCL was placed and compacted in lifts parallel to the subgrade, however, slopes were constructed by placing the soil in horizontal lifts. In either instance, a minimum of 6 to 8 or more passes with the compactor were applied to achieve the required degree of compaction. Approximately 11 acres of Cell 2 was covered with the RCL to a thickness of 5 feet.

6.6.3 Field Density Testing

Field density tests were performed by GCS as the RCL was placed and compacted. Testing was performed using nuclear methods ASTM D2922 and D3017. Per the project Specifications, the minimum percent compaction allowable was 90 percent of the modified Proctor maximum dry density as determined by ASTM test procedure D1557 and from 0 to 5 percent above the soil's optimum moisture content. Soil shear strengths were also taken periodically using a vane shear testing device. A total of 709 in situ density tests were performed on the RCL placed and compacted in Cell 2. Twenty-two of these initial tests initially failed to meet the project

Specifications and the corresponding areas were reworked and retested until passing results were achieved. The results of the RCL in situ density testing are summarized in Appendix Q.1.

In addition to the field testing, shelly tube samples were collected for hydraulic conductivity testing. The results of these hydraulic conductivity tests are presented in Appendix Q.2. As shown within the appendix, the results are less than 1×10^{-7} cm/s.

6.7 Primary Geomembrane Liner

6.7.1 General

The CQA activities performed by GCS during the installation of the primary geomembrane liner within Cell 2 consisted of:

- observation and documentation of primary geomembrane deployment procedures;
- observation and documentation of trial seam procedures and evaluation of test results;
- observation and documentation of field seams and seaming operations;
- location of seam destructive samples, performance of approximately 10 percent of the seam destructive testing, and evaluation of all the destructive testing results;
- observation and documentation of non-destructive seam continuity testing; and
- identification and documentation of defects as well as observation and documentation of repairs.

A detailed description of each of the above activities is presented in the following subsections.

6.7.2 Deployment Procedures and Observations

As required by the project Specifications, the RCL surface was certified and accepted by NSC for placement of the primary geomembrane liner. Copies of these certifications are included in Appendix R.

Geomembrane panels were deployed manually by pulling them from rolls suspended on a spreader bar attached to a rubber-tired front end loader or deployment cart. Following panel

deployment, the panels were aligned with a 5 inch overlap and were seamed using a double track fusion seaming device. Unbounded edges of geomembrane panels were temporarily loaded with sand bags to minimize the possibility of movement.

Each geomembrane panel was assigned a field identification number by GCS as it was deployed. After the panel was deployed, the edges of the lead, trail, and one side were measured with a micrometer to determine sheet thickness. After placement but prior to seaming, each panel was observed for damage and manufacturing imperfections. Observed defects were marked by GCS and were later repaired by NSC. A summary of the geomembrane panel deployment is included in Appendix S.

Periodically, points along the geomembrane panels were surveyed by MPS in order to locate field panels for development of a record drawing. A plan view of the primary geomembrane panel layout is shown on Figure 6.

6.7.3 Trial Seam Procedures and Observations

Trial seams were made by NSC from fragment pieces of geomembrane to verify that seaming conditions were adequate. Geomembrane trial seams approximately 10 feet in length were constructed under the same conditions as actual seams, typically three per day; once prior to the beginning of the initial seaming operation, once following the midday break, and at the end of the daily field seaming operations.

For each trial seam, a minimum of four specimens were obtained and tested. The specimens were tested in the peel adhesion (peel) and bonded seam strength (shear) modes. The mode of separation of each specimen tested was classified using the codes shown on Figure 8 for the double track fusion welding technique and Figure 9 for the extrusion welding technique. If a trial seam failed, the seaming apparatus and/or seamer prepared another seam which was retested. Retesting continued until deficiencies were corrected and a passing trial seam was obtained or until the decision was made not to use the particular seaming apparatus and/or seamer during the seaming period.

Each trial seam was assigned a unique number and the pertinent information recorded. A portion of each trial seam was archived by GCS for Ford. A summary of the fusion and extrusion trial seam information obtained throughout the installation of the primary geomembrane liner is included in Appendices T.1 and T.2, respectively.

On November 14, 1992, outside temperatures during trial seaming operations were measured below the 34 degree Fahrenheit project Specification. Therefore as noted within the extrusion trial seam summary, both geomembrane trial seam operations and repair procedures were carried out in heated enclosures. No production seaming occurred on that date.

6.7.4 Production Seaming

The principal seaming method used by NSC on this project was the double track fusion technique. This technique was employed for production seaming as the geomembrane panels were deployed. Alternative seaming methods used by NSC on this project were the solid wedge fusion and extrusion techniques. These methods were used primarily to repair defects in the geomembrane liner and perform tie in seams.

The various procedures associated with both fusion and extrusion seaming operations were observed by GCS. These observations included seam preparation, weather conditions during seaming, general seaming procedures, overlap of geomembrane panels, and temporary bonding procedures. All seams were observed throughout their length for quality and seam completion. Visually detected imperfections were marked by GCS and subsequently repaired by NSC. A summary of the geomembrane fusion and extrusion seaming information compiled by GCS is presented in Appendices U.1 and U.2, respectively.

6.7.5 Seam Non-Destructive Continuity Testing

All seam non-destructive continuity testing was performed by NSC to verify completeness and continuity of the seam. Two types of non-destructive testing were employed. Vacuum testing was performed on solid wedge fusion and extrusion welded seams and air pressure testing was

performed on double track fusion welded seams. This testing was visually observed by GCS and described in the following sections.

Vacuum testing consisted of applying a soapy solution to the weld area and placing a vacuum box over the segment to be tested. The vacuum box was connected via an air hose to a vacuum pump. When the vacuum box was "seated" properly, the pump would create a suction on the geomembrane. While the vacuum was held, the seam segment was observed through the viewing window for the presence of soap bubbles indicating leakage. If no leakage was found, the next adjoining area was tested, ensuring that a typical overlap of 3 inches was maintained. If a leak was detected it was marked for repair, repaired, and subsequently retested.

Pressure testing consisted of sealing the ends of the air channel created by a double track fusion seaming device. A needle/pressure gauge was then inserted into the air channel and the air channel was pressurized to at least 25 pounds per square inch (psi). The air channel was allowed to "relax" for a 2 minute interval, after which time the air pressure was noted. If the pressure had fallen below 25 psi, it was again pressurized to at least 25 psi and the pressure noted. The pressure was recorded 5 minutes after the relaxing period ended. If less than 2 psi of pressure was lost during the 5 minute period, the seam end opposite of the pressure gauge was cut. If the pressure gauge reading decreased to zero after the cut was made, the test was successful. If, however, the pressure had dropped more than 2 psi, or if the pressure gauge reading did not decrease to zero upon cutting the opposite end of the seam, the test failed. The process could be repeated in an attempt to isolate the failing area, but in any case, all failing seams or segments were marked for repair, repaired by extrusion seaming, and vacuum tested.

Summaries of the seam continuity testing for the landfill geomembrane fusion and extrusion welded seams are presented with the seaming summaries in Appendices U.1 and U.2, respectively.

6.7.6 Seam Strength Destructive Testing

Seam destructive samples were selected by GCS either randomly or because of a CQA monitor's suspicion of a defective seam. Of the approximately 35,783 linear feet of fusion and 17,476 linear feet of extrusion seaming and seam reconstruction or capping performed, 78 fusion and 36 extrusion seam destructive samples were obtained. The approximate resulting frequency of destructive testing was one per 459 linear feet of fusion seam and one per 485 linear feet of extrusion seam, which exceed project requirements.

GCS observed as NSC removed all the seam destructive samples from the welded geomembrane liner for testing. In general, two specimens from each destructive sample were first field tested in peel and shear by NSC using a portable tensiometer. If the field destructive test specimens passed, the remaining portion of the destructive sample was removed from the geomembrane liner installation for laboratory testing. A 12 inch segment was labelled and archived on-site by GCS for Ford and an 18 inch segment was labelled and shipped to the geosynthetic laboratory for testing. Approximately one of every ten samples were tested by GCS' geosynthetic laboratory while nine of ten were tested by NSC' geosynthetic laboratory. During laboratory testing of fusion seams, five specimens were evaluated for peel and five specimens were evaluated for shear. Since both the outside and inside of the weld area were tested for peel, a total of ten peel tests for each seam destructive sample were performed. The acceptance criteria for fusion welded seam specimens was the same as that for the extrusion welded test specimens in that four out of the five specimens must not fail in the weld area. Additionally, project requirements specified that peel adhesion exceed 128 pounds per inch yield strength and those tested for shear exceed 160 pounds per inch yield strength.

For an extrusion seam destructive sample, ten specimens were removed for testing; five specimens were tested for peel and five specimens were tested for shear. The acceptance criteria for peel specimens was that four out of five specimens must not fail in the weld area. Additionally, project requirements specified that peel adhesion must exceed 104 pounds per inch yield strength and those tested for shear exceed 160 pounds per inch yield strength.

Of the 78 initial fusion and 36 initial extrusion destructive samples taken, 18 fusion and 8 extrusion failed to meet project requirements. Each was tracked in both directions as welded and bound by passing destructive samples or completely reconstructed. All failed seam segments were repaired and non-destructively tested. Summaries of the primary geomembrane fusion and extrusion seam destructive test results are presented in Appendices V.1 and V.2, respectively.

6.7.7 Defects and Repair Observations

Geomembrane panels were initially monitored for damage during deployment. Additionally, GCS observed the geomembrane panels and seams on an on-going basis throughout the installation process. Each observed defect was documented, assigned a unique identification "Defect Code", marked, and subsequently repaired and vacuum tested by NSC. Repairs made to the geomembrane are summarized in Appendix W.

6.8 Leachate Collection and Removal System (LCRS)

6.8.1 General

The LCRS within the landfill is constructed directly over the primary liner system. The LCRS consists of geonet and geotextile across the cell slopes and a 1 foot thick Class 2NS sand blanket with leachate collection piping across the floor. The components of the LCRS are discussed in the following sections.

6.8.2 Geonet/Geotextile

As stated above, the LCRS across the slopes of Cell 2 was comprised of geonet and geotextile. Following completion of the primary geomembrane liner, geonet was deployed by orientating it lengthwise from the cell crest to the toe. The geonet rolls were allowed to extend past the toe and onto the cell floor a nominal amount. The geonet panels were overlapped a minimum of 4 inches and tied. The tie spacing used was 5 foot centers along the slopes, 2 foot centers across the slopes, and 6 inch centers in the anchor trench.

Two layers of 8 ounce per square yard geotextile overlies the geonet. Both layers are oriented lengthwise from the cell crest to the toe. The lower layer was placed directly over the geonet

and allowed to extend past the cell toe onto the floor a nominal amount. The upper layer of geotextile extended continuously across the top of the sand blanket on the cell floor. Both geotextile layers were overlapped 4 inches and continuously sewn into place.

6.8.3 Granular Drainage Material

The granular drainage material or sand used within the primary LCRS was processed and supplied by Milford Sand and Gravel from their Kent Lake Sand Pit. As specified, the sand is classified as 2NS by MDOT and consists of 100 percent minus 3/4 inch size and has an average permeability of 1×10^{-2} cm/s or greater. The sand testing performed on this project is discussed in Section 5.3.5. Summarized results of the testing is presented in Appendix D.2.2.

Once accepted for use, the sand was placed across the landfill floor to a minimum depth of 12 inches. The sand was spread evenly throughout the landfill using a low ground pressure dozer. GCS routinely checked the thickness of the sand blanket through the use of a sealed blunt probe. A summary of measured sand thicknesses is presented in Appendix X.

As the sand was spread across the landfill, the placement procedures used and the underlying geosynthetic layers were visually monitored by GCS. Monitoring was carried out to identify any potential damage occurring to the geosynthetics and to identify and minimize the occurrence of wrinkles.

6.8.4 Leachate Collection Piping

The leachate collection piping consisted of SDR 7.3 HDPE piping perforated at the bottom with two rows of 0.5 inch diameter holes 60 degrees apart and at 4 inch centers. A 6 inch diameter pipe was used around the perimeter of the cell floor and extended at 45 foot centers between the north and south toes of slope while an 8 inch diameter pipe was used as a main header extending between the east and west toes of slopes. Each pipe was covered with 6A stone and enclosed in geotextile.

The pipe was placed by first removing the sand material at the designed locations across the cell floor. Geotextile was then placed through the resulting trench. The leachate collection piping was installed above the geotextile with the perforation 30 degrees from either side of the invert. The 6A stone was placed around and over the pipe to a minimum thickness of 8 inches. The geotextile was wrapped around the gravel, overlapped a minimum of 4 inches, and continuously sewn together. Finally, the sand blanket was placed over the collection piping to a minimum thickness of 12 inches.

6.8.5 Primary Leachate Sump

The primary leachate collection sump is located centrally on the cell floor. Following completion of the geomembrane lining of the sump, the 300 mil HDPE sump box, measuring approximately 9 feet square and 3 feet deep, was positioned into the bottom of the sump. The 8 foot diameter and 12 inch thick precast concrete manhole base was then placed in the sump box and the 6 foot diameter corewall HDPE manhole was installed on top of the base.

Following manhole placement, a flowable fill (flyash cement) was used to fill the sump and sump box to the prescribed elevation. A void of approximately 2 inches located between the top of the flowable fill and the 80 mil "scuff" pad was filled with MDOT Class 2NS sand. The 80 mil "scuff" pad was extrusion welded, connecting the HDPE manhole welding ledge to the 80 mil sump liner.

The 8 inch diameter HDPE leachate collection header pipes were inserted into the manhole through cored openings. After the header pipes were inserted, each individual pipe was extrusion welded to the inside wall to complete the installation.

7.0 MECHANICAL/ELECTRICAL

The mechanical pump systems consisted of two wheeled sump drainers located within the artesian water removal sump and the secondary leachate monitoring removal sump. Both pumps are removable through riser pipes located on the south slope at surface entry ports. The primary leachate manhole contains a 4.5 horsepower submersible pump connected to a three inch HDPE forcemain installed from the primary HDPE manhole to an existing forcemain located on the south side of Cell 2. Installation of Valve Pit No. 1 provided a tie in to the existing 3 inch HDPE forcemain which was contained within a 6 inch PVC containment pipe.

GCS retained McNamee Industrial Services of Ann Arbor, Michigan to review all plans and Specifications for mechanical/electrical system approval. Representatives of the City of Allen Park Engineering Department made a final inspection which is required pursuant to the Mechanical Permit provided under contract provisions.

Electrical controls for the pump systems consisted of three control panels and one splice box. The artesian and secondary leachate collection pump control panels were contained in one weatherproof stainless steel enclosure. Each pump unit has a digital display for low level (off), high level (on) and high level alarm control functions. The primary leachate pump control panel is contained in a weatherproof stainless steel enclosure. The fluid levels and pump operation are controlled using float switches located within the primary manhole. A quick disconnect splice box was provided at the manhole location using a weatherproof stainless steel enclosure. This splice box was provided for pump maintenance disconnect and cable movement during fill operations. Electrical power was provided to this system from existing power panel, Box No. 2.

GCS retained McNamee Industrial Services to review and approve all electrical wiring cable and components specified in the construction plan. Representatives of the City of Allen Park made the final inspection required pursuant to the permit provided under contract provisions.

8.0 SURVEY CONTROL


Throughout the construction process, lines, grades, and thicknesses of the various components of Cell 2 were surveyed for compliance with the project Specifications by MPS. These surveys were performed typically using a "total station" system so that the elevations of discrete survey locations could be determined. Several of the drawings included in this report were obtained in part from MPS to represent the lines and grades of the final configuration. As stated previously, GCS also frequently measured thicknesses of various layers to check for compliance with project Specifications. These layers included compacted clay lift thickness, sand, and gravel thicknesses. Additionally, GCS would use field measurement techniques to approximate certain test locations.

9.0 SUMMARY

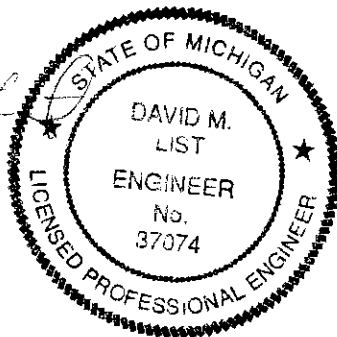
Golder Construction Services, Inc. was retained by Ford to provide third party CQA monitoring and testing services during the construction of the lining system within Phase I, Cell 2 at the Allen Park Clay Mine Landfill facility located in Allen Park, Michigan. Construction of the major components of the landfill included: the cell base floor; artesian water collection/removal system; secondary geomembrane liner; secondary leachate collection/removal system; recompacted clay liner; primary geomembrane liner; and the leachate collection/removal system.

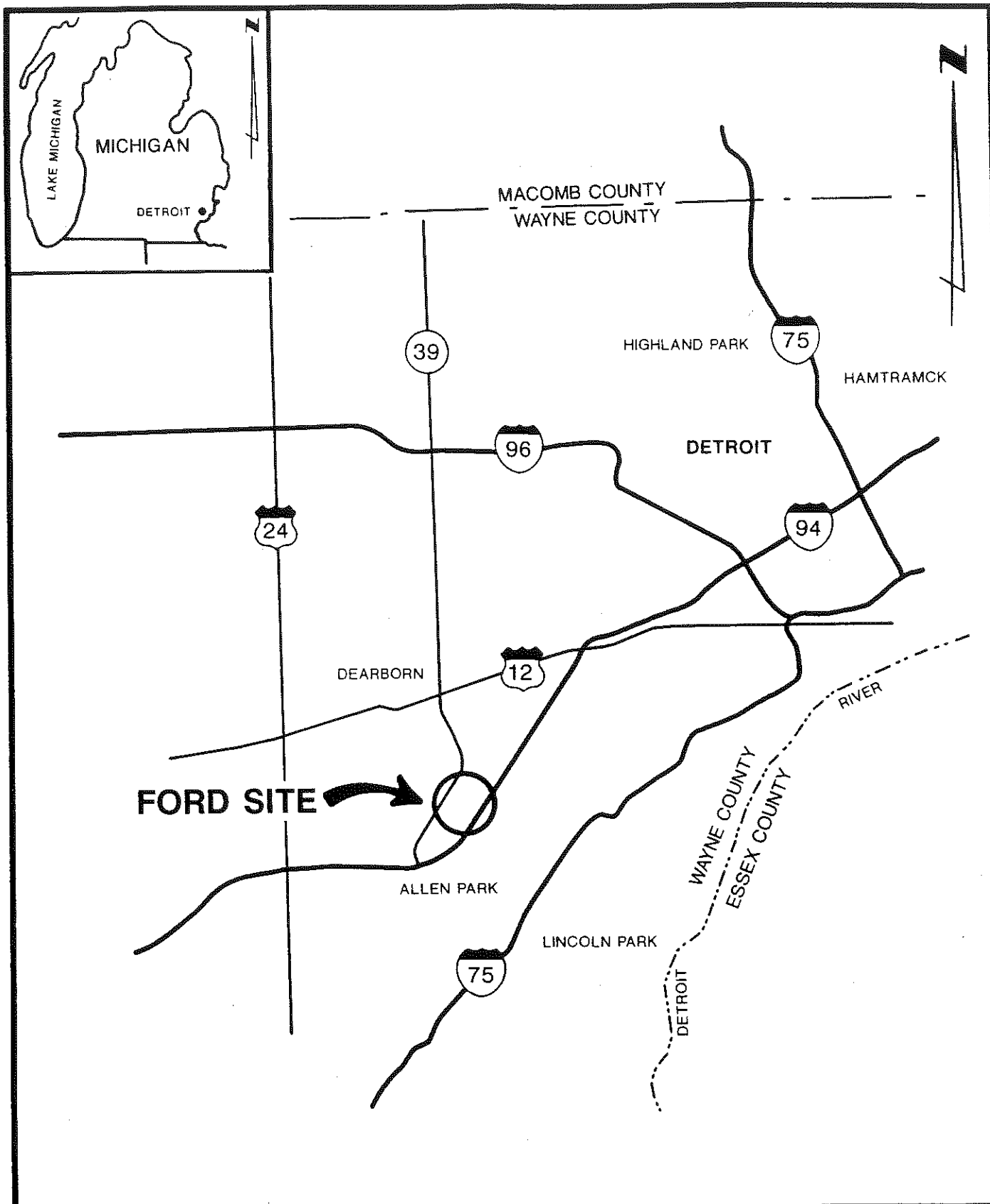
Based on the test results and the data presented herein as well as the observations made by GCS, the construction was carried out in substantial compliance with the facility Permit, design, technical specifications and CQA plans including modifications and collectively referred to as the project Specifications.

GOLDER CONSTRUCTION SERVICES, INC.


David M. List, P.E.
Senior Engineer

DML/JEW:laa





TITLE

**SITE LOCATION MAP
ALLEN PARK CLAY MINE FACILITY**

CLIENT/PROJECT

FORD MOTOR COMPANY

DRAWN

RJS

DATE

1/7/93

JOB NO.

917-1203

CHECKED

JKO

SCALE

N.T.S.

DWG NO.

REV. NO.

REVIEWED

JKO

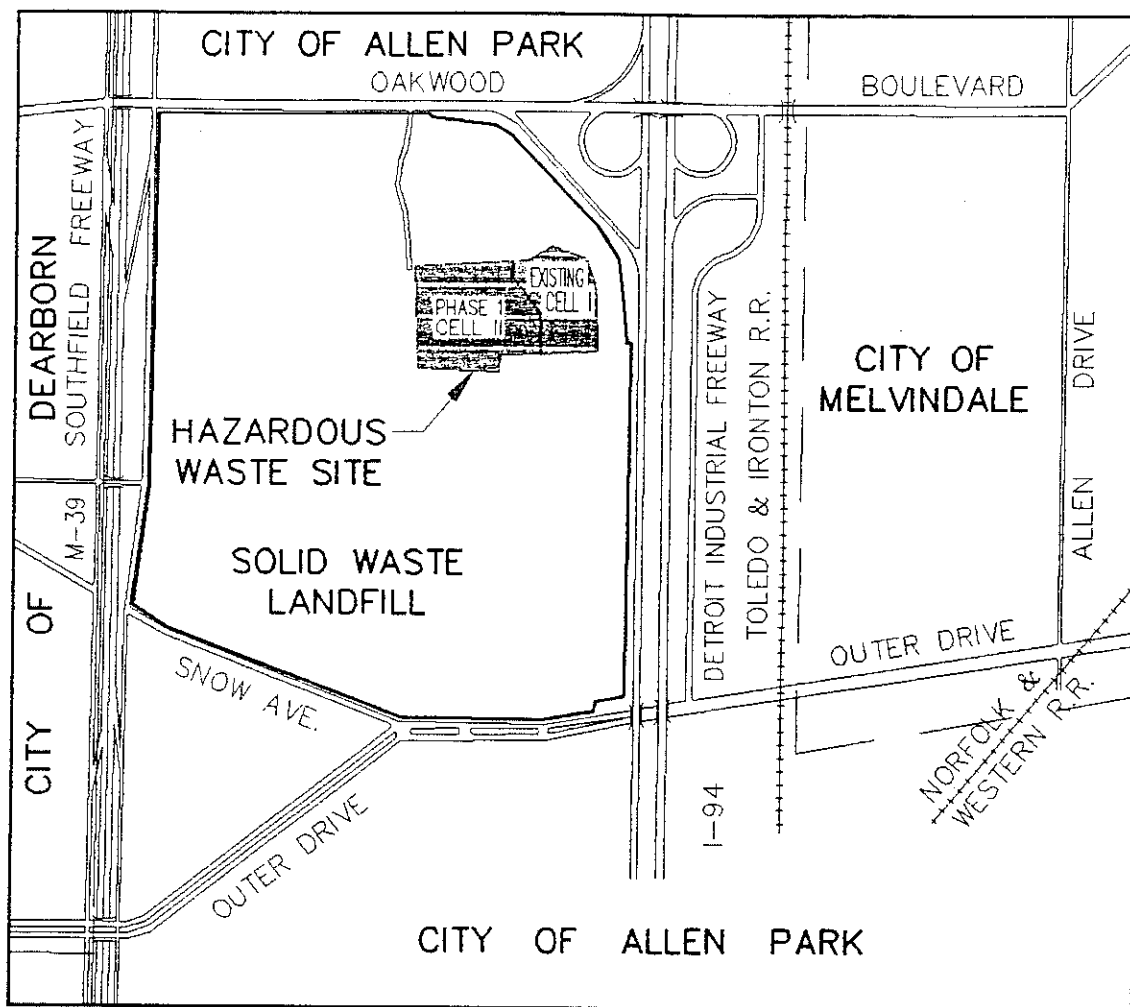
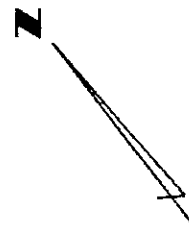
FILE NO.

917-1203

SUBTITLE

FIGURE NO. 1

N77309



CLIENT/PROJECT

FORD MOTOR COMPANY

TITLE

SITE PLAN

DRAWN	JAD	DATE	1/7/93	JOB NO.	917-1203
CHECKED	JKO	SCALE	N.T.S.	DWG NO.	REV. NO.
REVIEWED	JKO	FILE NO.	917-1203	SUBTITLE	FIGURE NO. 2

Untested specimen
Dual hot wedge fusion weld



Types of failure

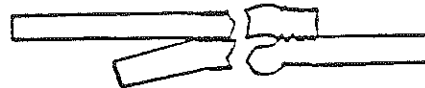
Pass/Fail
code

Description



FAIL 1

Adhesion failure



FAIL 2

FTB break at seam edge



FAIL 3

FTB break at second
seam edge



FAIL 4

FTB break at second
seam edge



PASS 1

FTB break in sheeting



PASS 2

FTB break at seam edge

Destructive sample test codes and description
for dual hot wedge fusion weld



CLIENT/PROJECT

FORD MOTOR COMPANY

TITLE

TRIAL SEAM SAMPLE TEST CODES
HOT WEDGE FUSION WELD

DRAWN

N/A

DATE

03-26-93

JOB NO.

917-1203

CHECKED

JAL

SCALE

NTS

DWG NO.

REV. NO.

REVIEWED

FILE NO.

917-1203


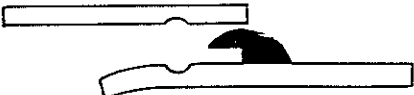

SUBTITLE



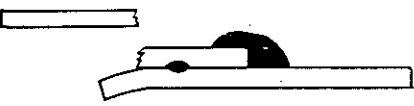



FIGURE NO.

7



Untested specimen
Extrusion weld with leister heat seam

Types of failure	Pass/Fail Code	Description
	FAIL 1	Adhesion Failure
	FAIL 2	Adhesion Failure
	FAIL 3	Adhesion Failure

	PASS 1	FTB welded seam edge
	PASS 2	FTB welded seam edge
	PASS 3	FTB heat seam edge
	PASS 4	FTB heat seam edge
	PASS 5	FTB welded seam edge
	PASS 6	FTB in sheeting

Destructive sample test codes and description for
extrusion weld



Golder Construction Services, Inc.
Quality Assurance and Construction Management

TITLE

TRIAL SEAM SAMPLE TEST CODES
EXTRUSION WELD WITH LEISTER HEAT SEAM

CLIENT/PROJECT

FORD MOTOR COMPANY

DRAWN

N/A

DATE

03-26-93

JOB NO.

917-1203

CHECKED

JAL

SCALE

NTS

DWG NO.

REV. NO.

REVIEWED

FILE NO.

917-1203

SUBTITLE

FIGURE NO. 8

NOVEMBER 1992

917-1203

GOLDER CONSTRUCTION SERVICES, INC.
PROJECT PERSONNEL
ALLEN PARK CLAY MINE - CELL 2
FORD MOTOR COMPANY

PERSONNEL	TITLE	INITIALS
DAVID M. LIST	PROJECT MANAGER/ CERTIFYING ENGINEER	DML
STEVEN R. SHEETS	CQA MONITOR	SRS
THOMAS A. HEASLEY	CQA MONITOR	TAH
MICHEAL AYERS	CQA MONITOR	MA
JEFF A. SHEPHARD	CQA MONITOR	JAS
ROBERT BUZZEL	CQA MONITOR	BB
JIM BANNER	CQA MONITOR	JB
DAVID ROTH	CQA MONITOR	DR
BARRY I. ESENE	CQA MONITOR	BIE
LORI E. LOZIER	CQA MONITOR	LEL
JAMES A. LOFTUS	CQA MONITOR	JAL
CASSANDRA A. WALKER	CQA MONITOR	CAW
A. WILLIAM JORDAN	CQA MONITOR	AWJ
BURILL F. McCOY	CQA MONITOR	BFM
F. WILL STALLARD	CQA MONITOR	FWS

FILENAME = GCSLIST.WK1

NATIONAL SEAL COMPANY
PROJECT PERSONNEL
ALLEN PARK CLAY MINE - CELL 2
FORD MOTOR COMPANY

PERSONNEL	TITLE	DESIGNATION
JAMES SCOTT SMITH	SUPERINTENDENT	126
BRIAN BOWMAN	TECHNICIAN TRAINEE	BB
CHANTHAVONE SOUNEVONGSA	TECHNICIAN	128
CHHUNLY TIM	TECHNICIAN	402
CLIFFORD JENKINS	TECHNICIAN	321
DAN BUTTS	TECHNICIAN	22
DAVE BRIESBROCK	TECHNICIAN	14
EDWARD MCCREARY	TECHNICIAN	184
ERIC TIMMERMAN	TECHNICIAN	138
GEORGE EGGER	TECHNICIAN	384
GREGORY DONLEY	SENIOR TECHNICIAN	33
JAMES HARGET	TECHNICIAN	51
JASON STEWART	TECHNICIAN	391
JOHN FIORENTINO	TECHNICIAN	410
JOSEPH DEPUE	TECHNICIAN	30
JOSEPH SANTA	QC TECHNICIAN	363
KETSANA VONGPHACHANH	TECHNICIAN	418
KEVIN ALLEN	SUPERINTENDENT	163
KHAMLA (LEM) SAYTHONGKHAM	TECHNICIAN	407
KIM JORDAN	QC TECHNICIAN	KJ
LEAN LONH	TECHNICIAN	210
LYLE HARPER	TECHNICIAN	318
MIKE BEEMAN	TECHNICIAN	5
MIKE FRENCH	TECHNICIAN TRAINEE	MF
MIKE SALAZAR	TECHNICIAN	115
KREAM NEANG	TECHNICIAN TRAINEE	NK
NHEP LONH	TECHNICIAN	208
PATRICK HIAR	FOREMAN	59
PHANOMPHONE SOUKCHANH	TECHNICIAN	398
PHETSAMONE KHATTIYAVONG	TECHNICIAN	76
PHETSAMONE VILAVANH	TECHNICIAN	146
PUCHO LEANIEZ	SUPERINTENDENT	193
RANDY BRUSH	FOREMAN	20
RATHA KIM	TECHNICIAN	209
RAYMOND HENDRICKS	TECHNICIAN	56
REASEY MAU	TECHNICIAN	345
RICHARD GONZALES	TECHNICIAN	45
RICKY STINSON	QC COORDINATOR	272
RITH SO	TECHNICIAN	RS
ROBERT LUDWIG	TECHNICIAN	174
ROEUN LUY	TECHNICIAN	317
SAMANTHYRA MAK	TECHNICIAN TRAINEE	406

NOVEMBER 1992

917-1203

NATIONAL SEAL COMPANY
PROJECT PERSONNEL
ALLEN PARK CLAY MINE - CELL 2
FORD MOTOR COMPANY

PERSONNEL	TITLE	DESIGNATION
SAYKHAM VONGSAKHAMPHOUY	TECHNICIAN	405
SIEBIE HUJER	TECHNICIAN	387
SOPHAL PRUM	TECHNICIAN TRAINEE	304
SOPHON TACH	TECHNICIAN	ST
SYSOUK PHETSAVAHN	TECHNICIAN	177
THONG INGELS	TECHNICIAN	195
THONGCHAN NOMICHIT	TECHNICIAN TRAINEE	382
TODD CLARK	TECHNICIAN TRAINEE	TC
TOM HARRELL	SUPERINTENDENT	53
TROY MORROW	TECHNICIAN	159
VANKHAM FRICHITHAVONG	TECHNICIAN	40
VANN THEA MEAN	TECHNICIAN TRAINEE	VM
VANXAY MATMANIVONG	TECHNICIAN	264
VETH PUTH	TECHNICIAN	417
VICKEY IRELAND	TECHNICIAN	66
VIENGTHONG NLN	TECHNICIAN	145
VOEUTH LOCH	TECHNICIAN	416
VUTHA KHAM	TECHNICIAN	202
WAYNE BERGMAN	TECHNICIAN	WB

FILENAME = NSCLIST.WK1

FORD MOTOR COMPANY
ALLEN PARK CLAY MINE LANDFILL
SUBGRADE ACCEPTANCE PROCEDURE
CELL II CONSTRUCTION

The procedure for subgrade preparation and acceptance for Cell II construction is summarized as follows:

- a) B&V shall proceed with final grading of the cell at any time prior to the placement of the liner. The CQA Officer will make the initial determination as to the acceptability of the surface. If the surface is unacceptable, preparation will continue until such time that the clay surface meets spec and the CQA Officer approves. Upon approval of the surface by the CQA officer Ford will accept responsibility for any repairs required due to washouts caused by rain. The Contractor shall remain responsible for any damage caused by his/her own equipment or Subcontractors, any additional preparation required to bring the surface into compliance with the Specifications due to oversight on the part of the Contractor and CQA Officer, ~~and shall also remain responsible for maintaining any final graded surface in a condition free from desiccation.~~ If the surface is damaged by a third party, Ford will retain B&V to make the necessary repairs at the expense of the third party.
- b) At the 9:00am liner meeting the liner installer will indicate the amount and location of area to be lined the following day. The CQA Officer will reinspect the surface and make the initial determination as to the acceptability of the surface. If the surface is unacceptable, preparation will begin and continue that day until it meets spec and the CQA Officer approves. Financial responsibility for the repairs will be dictated by the circumstances as presented in a) above.
- c) The subject area is worked on by B&V that day under the observation of the CQA Officer. The area is targeted for completion by 3:30pm the same day it is requested. The CQA Officer will make the initial determination as to the acceptability of the surface. If the surface is unacceptable, preparation will continue that day until it meets spec and the CQA Officer approves.
- d) Upon acceptance by the CQA Officer, tentatively planned for approximately 3:30pm daily, the liner installer will be asked to give a determination as to the acceptability of the surface for the following day, providing conditions of the surface do not change. If the surface is acceptable to the liner installer, work on the surface is completed for the day. If the surface is unacceptable to the liner installer, preparation continues that day until it meets spec and has the preliminary approval of both the CQA Officer and the liner installer. Ford Motor Company will assume responsibility for the surface upon this preliminary acceptance in the event of washout due to rain. B&V will retain responsibility for ~~desiccation cracking or~~ any "out of spec" conditions which were not identified during the preliminary acceptance period. The prepared surface area will be turned over to the liner installer the following morning.
- e) In the event that the area is turned over to the liner installer and at some point during the daily installation the surface becomes eroded by rain, Ford will retain B&V to make repairs as required to bring the surface back into an acceptable condition.



NTH Consultants, Ltd.

38955 Hills Tech Drive, • P.O. Box 9173, Farmington Hills, Michigan 48333-9173 • (313) 553-6300 • Fax: (313) 489-0727

April 27, 1993
NTH Project No. 13-9365-03

Mr. Jeffrey L. Hartlund, P.E.
Environmental Control Engineer
Environmental Quality Office
15201 Century Drive, Suite 602
Dearborn, MI 48120

RE: Specification Clarifications
Allen Park Clay Mine Landfill - Cell II
Allen Park, Michigan

Dear Mr. Hartlund:

This letter presents clarifications to the specifications of Cell II of Allen Park Clay Mine Landfill (APCML). The clarifications describe design requirements for the geosynthetic drainage layer (geonet) and geomembrane intended for use in the construction of the double-composite liner system. These clarifications have been verbally presented to involved parties during the construction of the cell. Background data and our clarifications are described in the following paragraphs.

Cell II of APCML has been permitted as a Hazardous Waste Disposal Area. NTH Consultants, the design engineer, presented the project specifications in a document entitled "Specification No. APCML91-5, Type I Hazardous Waste Cell Construction", issued June, 1989 and revised March 18, 1992. The construction of the cell is expected to be completed in April 1993.

The cell design calls for the construction of a double-composite liner system. This system consists of the following components, from bottom upward: (1) secondary clay liner; (2) seepage water collection system consisting of geonet, geotextile and piping system; (3) secondary flexible membrane liner; (4) leak detection system consisting of geonet, geotextile and piping system; (5) primary liner system consisting of five feet of compacted clay overlain by a flexible membrane liner; and (6) leachate collection system consisting of geonet, geotextile, sand, gravel and piping system.

During construction operations, clarifications of the specifications were requested regarding the cross direction tensile strength and transmissivity of the geonet and hardness of the

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Mr. Jeffrey L. Hartlund
Project No. 13-9365-03
April 27, 1993
Page 2

geomembrane intended for use in the construction of the double-composite liner system. These clarifications are summarized below:

Geosynthetic Drainage Layer (Geonet):

Cross Direction Tensile Strength - The geonet is not a structural member and is not designed to be subjected to tensile stresses. However, the geonet will sustain some tensile stresses due to temperature changes or self weight when installed on slopes. The geonet must have enough tensile strength to withstand such stresses. It is our professional opinion that, in the cross direction, a tensile strength of 28 pounds per linear inch is sufficient to withstand these stresses in normal conditions.

Cross Direction Transmissivity - Based on the results of our design calculations, the required transmissivity for the geonet to transfer the expected flow in the seepage, leak detection, and leachate collection systems is equal to or greater than 1.5×10^{-9} m²/sec.

Flexible Membrane Liner:

Hardness - The average hardness for the liner material must be greater than or equal 60 Shore D. The value shown in the project specifications (hardness less than or equal 60 Shore D) is a typographic error. As shown in the project specifications, the specimen minimum and maximum values are 54 and 66 Shore D, respectively.

We trust that this letter provides sufficient information for your current needs. If you have any questions, do not hesitate to contact us.

Sincerely,

NTH CONSULTANTS, LTD.

Ibraheem S. Alshunnar
Ibraheem S. Alshunnar
Project Engineer

Benedict Tiseo
Benedict Tiseo, P.E.
President

ISA/BT/pd

**RESULTS OF
FINGERPRINT TESTS
CONDUCTED ON GEOMEMBRANE,
GEOTEXTILE, GEONET, AND PIPE**

Prepared for

Golder Construction Services
7205 Abbott Road
East Lansing, MI 48823

Prepared by

GeoSyntec Consultants
Materials Testing Laboratory
3050 S.W. 14th Place, Suite 18
Boynton Beach, Florida 33426

GeoSyntec Consultants Project No. MC5148

18 November 1992

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- 4.2.5 Mass per Unit Area and Thickness
- 4.2.6 Geotextile Summary

4.3 Conwed Geonet

- 4.3.1 Differential Scanning Calorimetry
- 4.3.2 Thermal Gravimetric Analysis
- 4.3.3 Structural Analysis
- 4.3.4 Melt Index
- 4.3.5 Mass per Unit Area and Thickness
- 4.3.6 Summary of Geonet Results

4.4 Pipes

- 4.4.1 Differential Scanning Calorimetry
 - 4.4.1.1 Archive and New Pipe Samples
 - 4.4.1.2 Archive and Site Pipe Samples
- 4.4.2 Thermal Gravimetric Analysis
- 4.4.3 Structural Analysis
- 4.4.4 Melt Index
- 4.4.5 Pipe Summary

5. CONCLUSIONS

6. REFERENCE

1. INTRODUCTION

GeoSyntec Consultants' Materials Testing Laboratory (GeoSyntec Consultants) prepared this report as requested by Mr. David List of Golder Construction Services, Inc. (Golder). GeoSyntec Consultants was asked to fingerprint geosynthetic samples taken from the Ford Motor Company site. GeoSyntec Consultants was also asked to compare the results of this test program with results obtained previously in the Wayne Disposal chemical compatibility project (GeoSyntec Job Number G87-294). The previous test program, conducted according to a test protocol developed by RMT, Inc. and GeoSyntec Consultants, was completed in 1988.

2. TEST PROGRAM

In this program, the following geosynthetics were fingerprinted:

- National Seal Company (NSC) polyethylene (PE) geomembrane;
- Amoco polypropylene (PP) geotextile;
- Conwed (PE) geonet; and
- two samples of Plexco high density polyethylene (HDPE) pipe, one sample from the site and one new sample.

The following properties measured:

<u>Property</u>	<u>Method</u>
Crystallinity	ASTM E 793
Oxidative Induction Temperature (OIT)	Differential Scanning Calorimetry (DSC)
Composition	Thermal Gravimetric Analysis (TGA)

Structural Properties	Infrared Spectrophotometry (IR)
Melt Flow Index (MFI)	ASTM D 1238
Mass per Unit Area*	ASTM D 3776
Thickness*	ASTM D 1777

* Measured only on geonet and geotextile.

The specific test details are provided in Section 3.

3. TEST DETAILS

3.1 Test Parameters

The specific test parameters are presented below.

Crystallinity - A Perkin Elmer DSC IV with a system IV microprocessor and model 3700 data acquisition facility was used. The analysis was conducted according to ASTM E 793, "Test Methods for Heats of Fusion and Crystallization by Differential Scanning Calorimetry". The analyses were run in nitrogen using a heating rate of 20°C/min.

OIT - A Perkin Elmer DSC IV with a system IV microprocessor and model 3700 data acquisition facility was used. The analyses were conducted in air, using a heating rate of 20°C/min.

Composition - A Perkin Elmer TGS II with a system IV microprocessor and model 3700 data processing and acquisition facility was used. The analyses were conducted in nitrogen at a heating rate of 40°C/min.

MFI - MFI values were obtained using ASTM D 1238, "Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer".

Thickness - ASTM D 1777, "Method for Measuring Thickness of Textile Materials".

Mass Per Unit Area - ASTM D 3776, "Test Methods for Mass Per Unit Area of Woven Fabrics".

3.2 Microstructural Test Description

Microstructural test methods were used in this test program. Such test methods are typically used for polymer characterization. A description of the microstructural test methods is provided below.

3.2.1 DSC

DSC measures the thermal properties of a material. In a DSC analysis, a sample is heated at a controlled rate, and the samples absorption or emission of heat is measured. When a sample absorbs heat, an endotherm is generated. A sample's emission of heat generates an exotherm. Endotherms and exotherms are described below.

3.2.1.1 Endotherms

Endotherms are curves generated by DSC, showing the amount of heat absorbed by a sample. The area under the curve is associated with heat absorbed by the sample. Samples absorb heat when they melt. The amount of heat absorbed by a sample when it melts is associated with its crystallinity. Accordingly, from the area under the endotherm, the crystallinity of a sample can be calculated.

3.2.1.2 Exotherms

Exotherms are related to the amount of heat emitted by a sample. A sample emits heat when it undergoes oxidation. The temperature at the onset of the sample's reaction with oxygen occurs, is the sample's oxidative induction temperature (OIT) and is associated with its oxidative stability.

3.2.2 TGA

TGA monitors a sample's weight as the sample's temperature is increased at a controlled rate. As a sample is heated, its components decompose, and accordingly, the sample loses weight equal to the components' weight. Having different thermal stabilities, the components decompose at different temperatures. Because a sample's weight is monitored as a function of temperature, it is possible to calculate a sample's percentage composition. TGA generates a weight loss diagram of a sample.

3.2.3 IR

Molecular structure is analyzed using infrared spectrophotometry (IR), a technique that subjects a sample to infrared radiation. Molecules consist of individual components that each respond, at different frequencies, to infrared radiation. When the infrared frequency matches the vibrational frequency of a molecular component, the molecular component absorbs infrared radiation. After a sample has been exposed to infrared radiation, an infrared spectrum of the sample is obtained. Every material has a unique infrared spectrum, making IR a useful technique for characterizing materials.

4. RESULTS AND DISCUSSION

4.1 NSC Geomembrane

4.1.1 Differential Scanning Calorimetry

The results of the NSC geomembrane's DSC analysis, derived from the geomembrane's endotherms and exotherms, are presented in Table 1. The endotherms and exotherms are provided in Appendix A.

TABLE 1. DSC Analysis of the NSC Geomembrane

<u>Property</u>	<u>Unit</u>	<u>Archive</u>	<u>New</u>
Crystallinity	%	56	51
Oxidative Induction Temperature	°C	252	276

The archive and new NSC geomembranes have similar crystallinity and OIT results, indicating that the geomembranes probably have similar morphologies. The small differences are within the expected range for inherent material variability. In addition, the new sample's higher OIT result indicates that the antioxidant package now being used is more effective than the one used in the archive sample.

4.1.2 Thermal Gravimetric Analysis

The results of thermal gravimetric analysis are presented in Table 2. The results were derived from weight loss diagrams provided in Appendix B.

TABLE 2. TGA Analysis of the NSC Geomembrane

<u>Property</u>	<u>Unit</u>	<u>Archive</u>	<u>New</u>
Volatiles	%	0.00	1.34
Polymer	%	96.04	95.99
Residue	%	3.96	2.67

As with results of crystallinity and OIT, the archive and new geomembranes' composition results are similar, indicating that the geomembranes are of nearly equivalent formulations. The small differences are probably due to the inherent material variability of the geomembranes.

4.1.3 Structural Analysis

The results of infrared analysis of the archive and of the new NSC geomembranes, respectively, are presented in Figures 1 and 2.

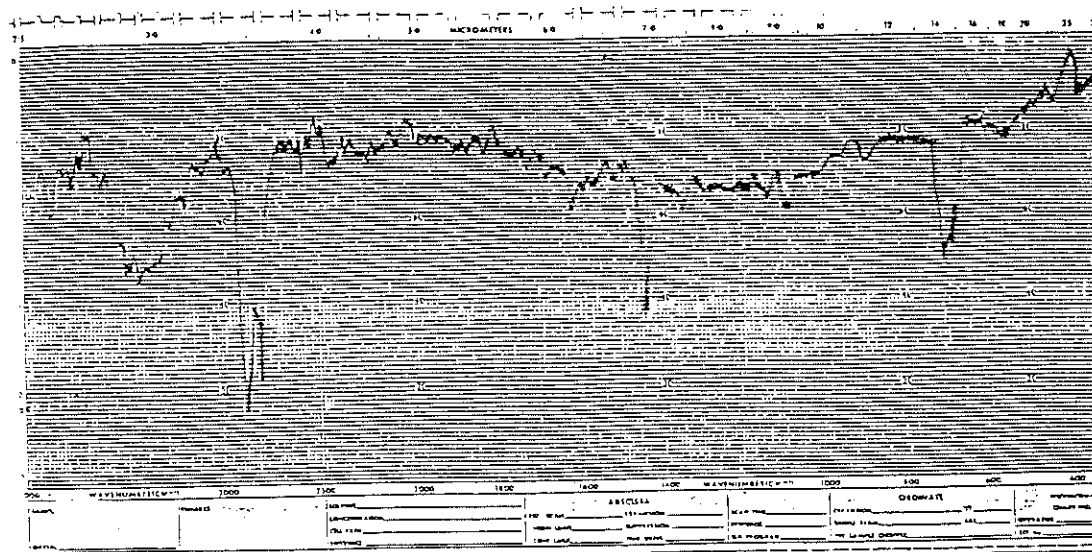


Figure 1. IR Analysis of the Archive NSC Geomembrane

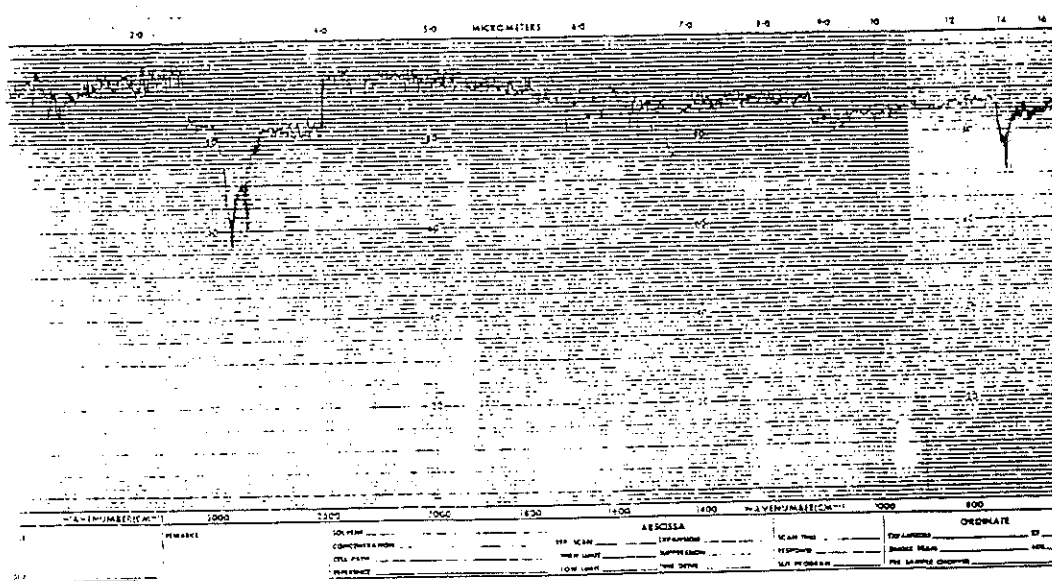


Figure 2. IR Analysis of the New NSC Geomembrane

Examination of Figures 1 and 2 reveals that the IR spectra for the archive and the new NSC geomembranes are nearly identical. Based on the spectral characteristics, the IR spectra verify that the geomembranes are polyethylene based [ASTM D 276]. The small differences in band heights is attributed to sample preparation, a procedure that may affect spectral band height, but not band appearance or position.

4.1.4 Melt Index

The melt index values for the archive and new NSC geomembranes are 0.5100 g/10 min and 0.3400 g/10 min respectively. The melt index values differ slightly, indicating that changes in the resin, according to the manufacturer, were made to improve its processability, changes that should not alter the performance of the geomembrane.

4.1.5 Geomembrane Summary

The geomembranes' properties were generally very similar, indicating equivalency in the geomembranes' formulation. The small differences in OIT and melt index may be attributed to improvements in the new geomembrane's formulation. Such changes should improve the performance of the new geomembrane.

4.2 Amoco Geotextile

4.2.1 Differential Scanning Calorimetry

The results of the Amoco geotextile's DSC analysis, derived from the geomembrane's endotherms and exotherms, are presented in Table 3. The endotherms and exotherms are provided in Appendix A.

TABLE 3. DSC Analysis of the Amoco Geotextile

<u>Property</u>	<u>Unit</u>	<u>Archive</u>	<u>New</u>
Crystallinity	cal/g	27	25
Oxidative Induction Temperature	°C	211	215

Inspection of Table 3 reveals that the archive and new geotextiles have nearly the same crystallinity and OIT values. The small differences may be attributed to inherent material variability.

4.2.2 Thermal Gravimetric Analysis

The results of thermal gravimetric analysis of the archive and new Amoco geotextile are presented in Table 4. The results were derived from weight loss diagrams provided in Appendix B.

TABLE 4. TGA of the Amoco Geotextile

<u>Property</u>	<u>Unit</u>	<u>Archive</u>	<u>New</u>
Volatiles	%	1.49	0.69
Polymer	%	97.49	97.64
Residue	%	1.02	1.66

Evaluation of the geotextiles' TGA indicates that their composition is very similar. As with their crystallinity and OIT results, the geotextiles' composition also shows small differences. Such differences may be attributed to inherent material variability, since TGA isolates localized extremes in composition, extremes which are artifacts of the small sample size required for the analysis. These results indicate that the geotextiles' are equivalent compositionally.

4.2.3 Structural Analysis

The results of infrared analysis of the archive and of the new Amoco geotextiles are presented Figures 3 and 4 respectively.

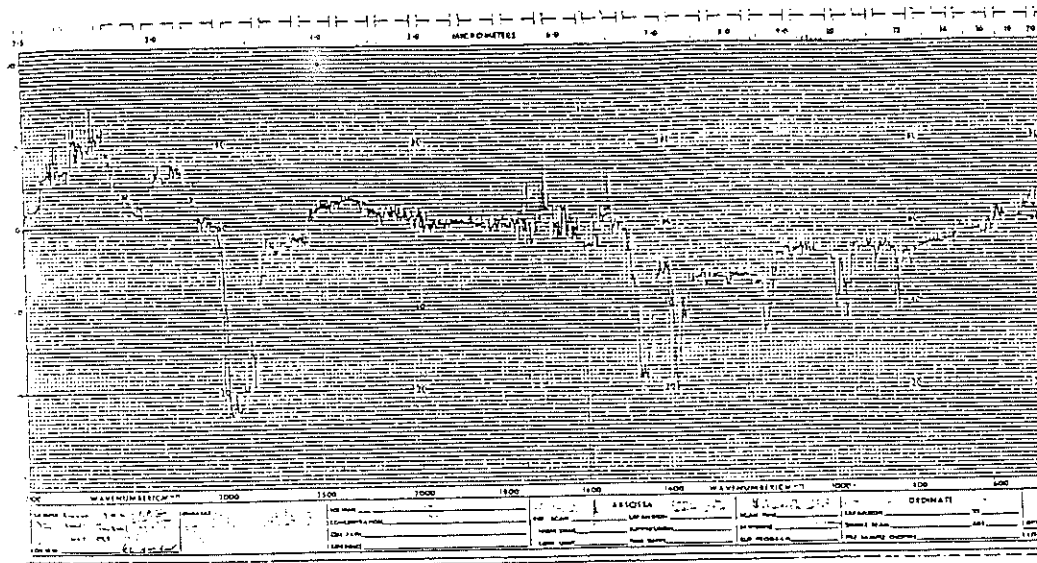


Figure 3. IR Analysis of the Archive Amoco Geotextile

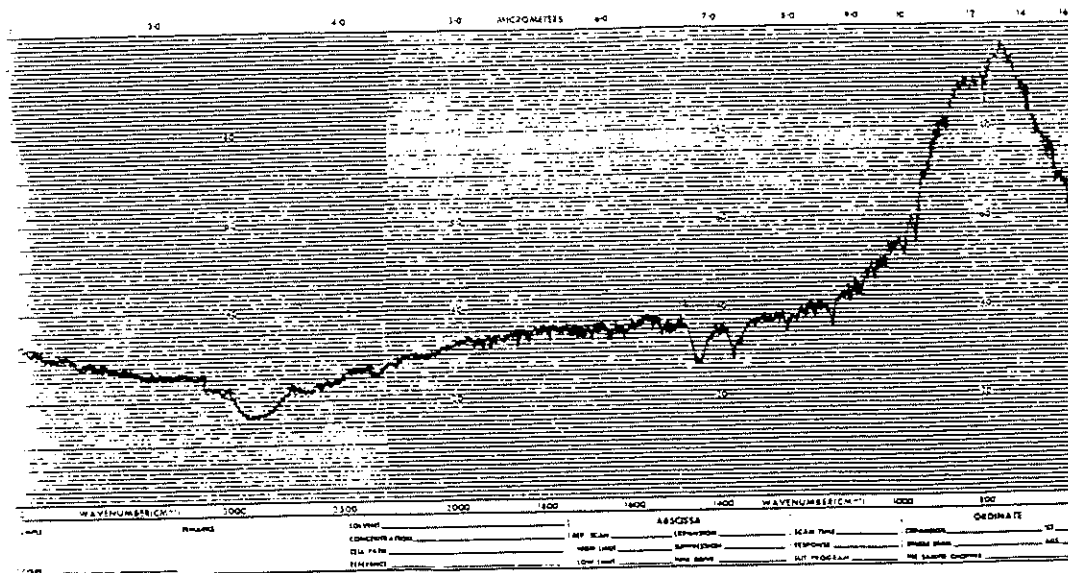


Figure 4. IR Analysis of the New Amoco Geotextile

Examination of the IR spectra for the archive and the new geotextiles reveals that the geotextiles have the same molecular structure because their spectra are identical. The spectra are consistent with polypropylene's spectrum [ASTM D 276]. The small differences in the band heights may be attributed to variances in sample preparation, a process that can affect IR band height.

4.2.4 Melt Index

The melt index values for new Amoco geotextile is 5.0856 g/10 min. The geotextiles' melt index in the original test program was not evaluated; therefore, no melt index value is being reported for the archive geotextile.

4.2.5 Mass per Unit Area and Thickness

The mass per unit area and thickness values for the archive and new Amoco geotextile are reported in Table 5.

Table 5. Mass/Area and Thickness Results

<u>Property</u>	<u>Unit</u>	<u>Archive</u>	<u>New</u>
Mass per Unit Area	oz/yd ²	8.6	8.6
Thickness	in.	0.09	0.09

Evaluation of the data reported in Table 5 indicates that the thickness and mass per unit area of the archive and the new geotextiles are the same.

4.2.6 Geotextile Summary

Results of the geotextile fingerprinting tests indicate that the geotextiles are generally equivalent. The small differences in crystallinity, OIT, and composition are attributed to inherent material variability. The differences in the geotextiles' IR spectra is due to variations in sample preparation. Therefore, the archive and new geotextiles appear generally to be equivalent.

4.3 Conwed Geonet

4.3.1 Differential Scanning Calorimetry

The Conwed geonet's DSC analysis results, derived from its endotherms and exotherms, are presented in Table 6. The endotherms and exotherms are provided in Appendix A.

TABLE 6. DSC Analysis of the Conwed Geotextile

<u>Property</u>	<u>Unit</u>	<u>Archive</u>	<u>New</u>
Crystallinity	%	41	40
Oxidative Induction Temperature	°C	244	261

The results of DSC analysis of the geonet indicate that the archive and new geonets have very similar formulations. Slightly higher than the archive sample value, the new geonet's OIT value indicates that it contains a more effective antioxidant. Moreover, both samples have nearly the same crystallinity values have nearly the same crystallinity values, indicating that they are of equivalent morphology.

4.3.2 Thermal Gravimetric Analysis

The archive and new geonet TGA results are presented in Table 7. The results were derived from weight loss diagrams provided in Appendix B.

TABLE 7. TGA Analysis of the Conwed Geonet

<u>Property</u>	<u>Unit</u>	<u>Archive</u>	<u>New</u>
Volatiles	%	1.03	0.27
Polymer	%	98.38	97.65
Residue	%	0.59	2.07

The TGA results show some differences; however, these differences can be expected in TGA results, since TGA is sensitive to isolated variations in a material's composition.

4.3.3 Structural Analysis

The results of infrared analysis of the archive and of the new Conwed geonet respectively are presented Figures 5 and 6.

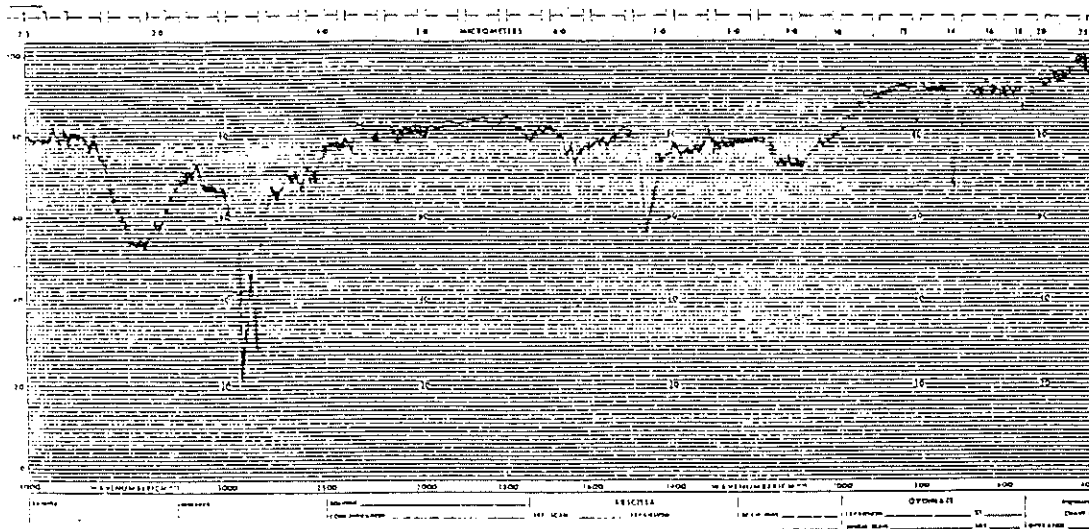


Figure 5. IR Analysis of the Archive Conwed Geonet

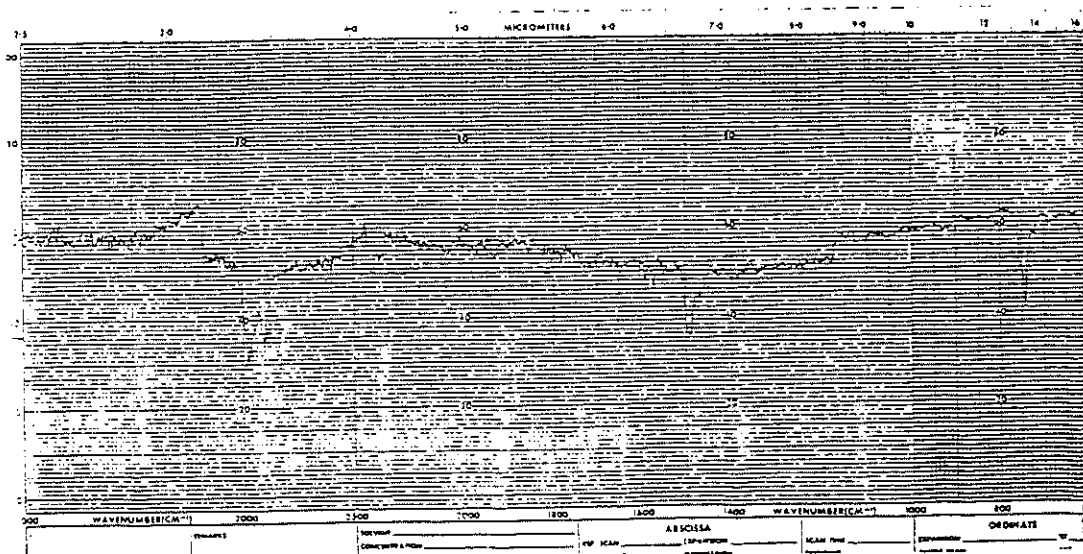


Figure 6. IR Analysis of the New Conwed Geonet

Examination of Figures 5 and 6 reveals that the IR spectra for the archive and the new geonet samples are the same. The spectra verify that the geonets are polyethylene based [ASTM D 276].

4.3.4 MFI

The original archive value, 0.169 g/10 min, was much below that of the new geonet and was lower than the manufacturer's data (approximately 0.9 g/10 min). Because of the large difference, the archive sample was retested. The MFI value for the archive geonet, according to the retest, is 0.8920 g/10 min and the new geonet's value is 0.9991 g/10 min. The new archive value, 0.8920 g/10 min, is consistent with the expected manufacturer's value. Using the archive sample's retest MFI value for comparison, the MFI values for the archive and new geonets are very similar. Such a similarity indicates that the archive and new geonets were made of nearly equivalent resins.

4.3.5 Mass per Unit Area and Thickness

The new Conwed geonet's mass per unit area and thickness values are 32.9 oz/yd² and 0.3 in respectively. In the original test program, archive geonet's mass per unit area and thickness were not measured.

4.3.6 Summary of Geonet Results

The properties of the archive and of the new geonet generally appear to be similar, indicating that the geonets were probably made from equivalent formulations. The small differences are most likely attributed to inherent material variability.

4.4 Pipes

4.4.1 Differential Scanning Calorimetry

The results of the Plexco pipes' DSC analysis, derived from the pipes' endotherms and exotherms, are presented in Table 8. The endotherms and exotherms are provided in Appendix A.

TABLE 8. DSC Analysis of the Plexco Pipes

<u>Property</u>	<u>Unit</u>	<u>Archive</u>	<u>Site-Sample</u>	<u>New</u>
Crystallinity	%	34	53	49
Oxidative Induction Temperature	°C	245	183	272

Inspection of Table 8 reveals that the pipes have some differences in their crystallinity and in their OIT values. The differences between the archive sample and the new sample will be discussed first, followed by a discussion on the differences between the archive and the site-sample.

4.4.1.1 Archive and New Pipe Samples

The archive and new pipe samples show some difference in crystallinity. Because DSC measures crystallinity in very small specimens, isolated extremes in a material's crystallinity can be observed. The low crystallinity value of the archive pipe (34%) is attributed to this effect. The new sample's crystallinity value is consistent with those obtained typically in polyethylene pipe materials.

The OIT value for the new sample is slightly higher than that of the archive sample, indicating that the new sample has a more effective stabilizer package.

4.4.1.2 Archive and Site Pipe Samples

As discussed in Section 4.4.1.1, the crystallinity values of the archive and of the site sample pipes show a difference similar to that between the archive and the new pipe sample, attributed to the normal isolated extremes in the material's crystallinity.

The site sample's OIT is significantly lower than the archive sample's OIT, indicating that the site sample had been exposed to sunlight. Ultraviolet radiation and heat from sunlight consume antioxidants, reflected in the site sample's lower OIT value.

4.4.2 Thermal Gravimetric Analysis

Derived from weight loss diagrams provided in Appendix B, the results of thermal gravimetric analysis of the Plexco pipes are presented in Table 9.

TABLE 9. TGA of the Plexco Pipes

<u>Property</u>	<u>Unit</u>	<u>Archive</u>	<u>Site-Sample</u>	<u>New</u>
Volatiles	%	0.00	0.09	0.80
Polymer	%	96.60	95.62	96.44
Residue	%	3.40	4.29	2.75

The results of TGA for the pipe samples are generally similar, indicating that the pipes were made from the same basic compositional formulations, which are typical of polyethylene pipe materials.

4.4.3 Structural Analysis

The results of infrared analysis of the Plexco pipes are presented in Figures 7, 8, and 9.

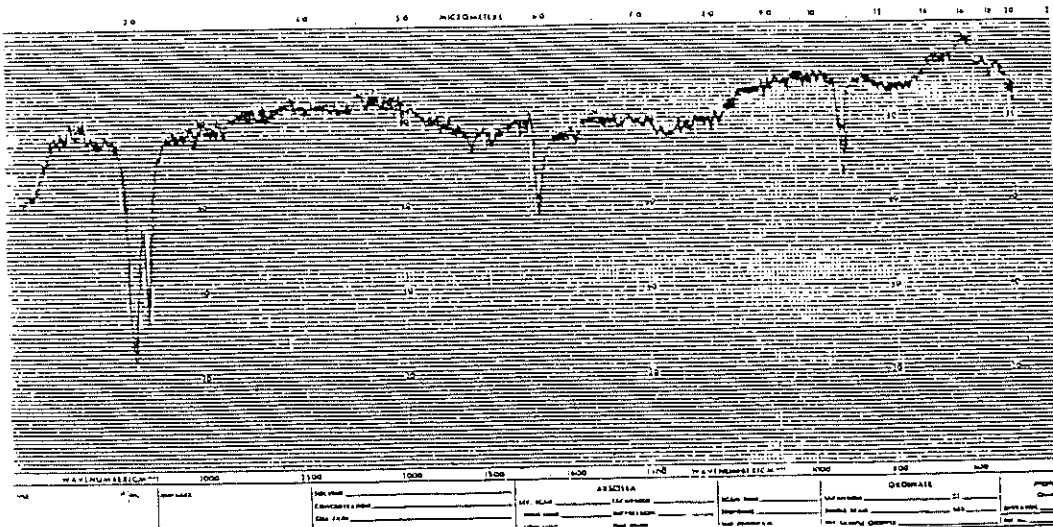


Figure 7. IR Analysis of the Archive Plexco Pipe

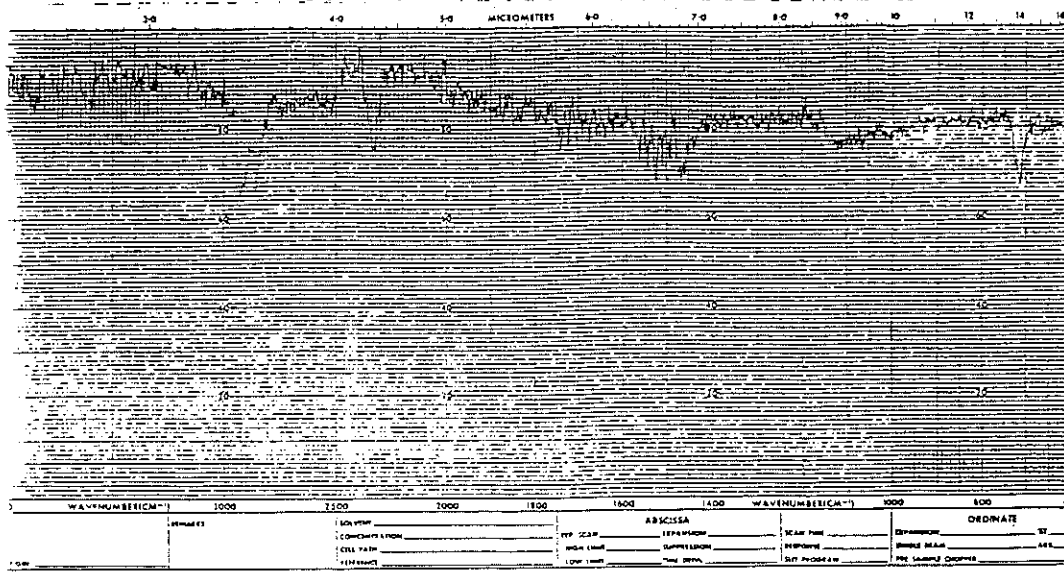


Figure 8. IR Analysis of Site-Sample

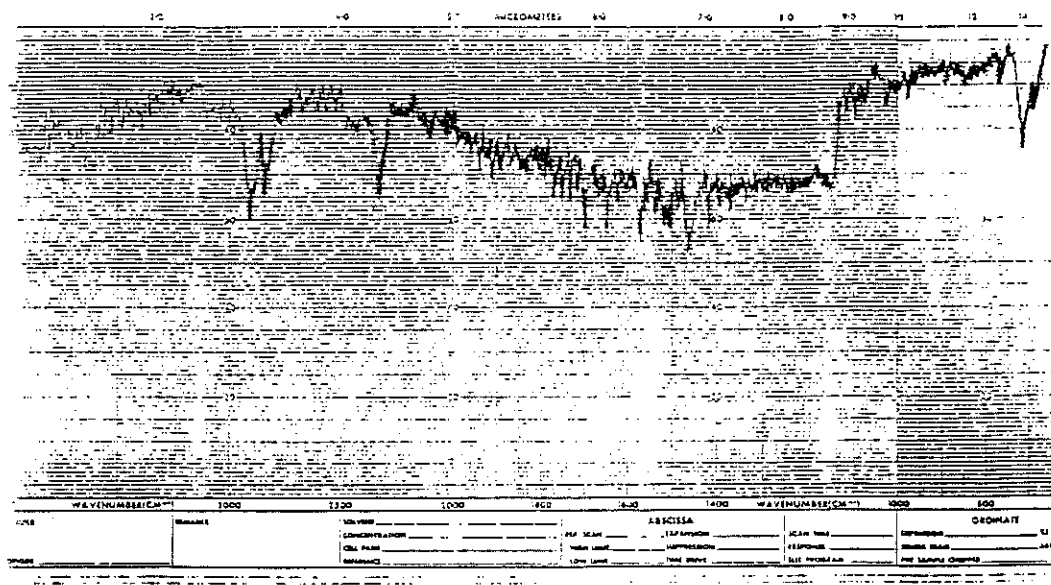


Figure 9. IR Analysis of New Plexco Pipe

Examination of the pipes' IR spectra reveals that the spectra are nearly identical, and as expected, reveals that the pipes are polyethylene based [ASTM D 276].

4.4.4 MFI

The MFI values for the archive, site-sample, and new Plexco pipes are 0.0800 g/10 min, 0.1185 g/10 min, and 0.1122 g/10 min respectively. The values are generally similar, indicating that the pipes' base resins are similar.

4.4.5 Pipe Summary

The pipes' fingerprinting tests indicate that the pipes are generally equivalent. The most significant difference is between the site sample and the archive and new pipe samples, a difference attributed to the site sample's exposure at the site.

5. CONCLUSIONS

Fingerprint analysis of the geosynthetics indicated that the geosynthetics are generally equivalent in formulation. Small differences were observed between some of the archive and new samples; however, these differences were attributed to material variability. The largest difference was found between the site pipe sample and the archive and new pipe samples, a difference attributed to the site pipe sample's outdoor exposure. In conclusion, these fingerprinting tests indicate that the new geosynthetics are generally equivalent to their respective archive samples.

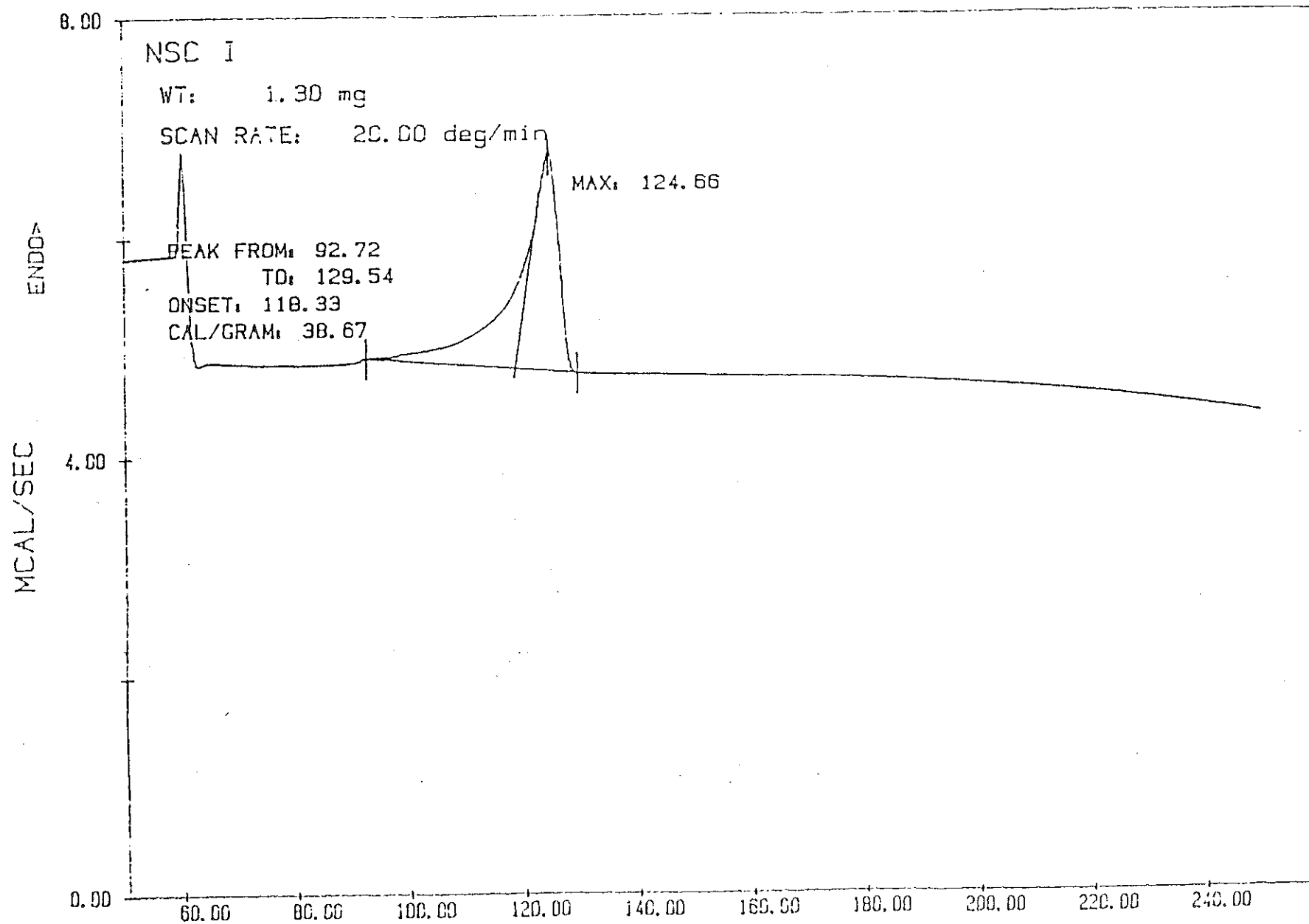
6. REFERENCE

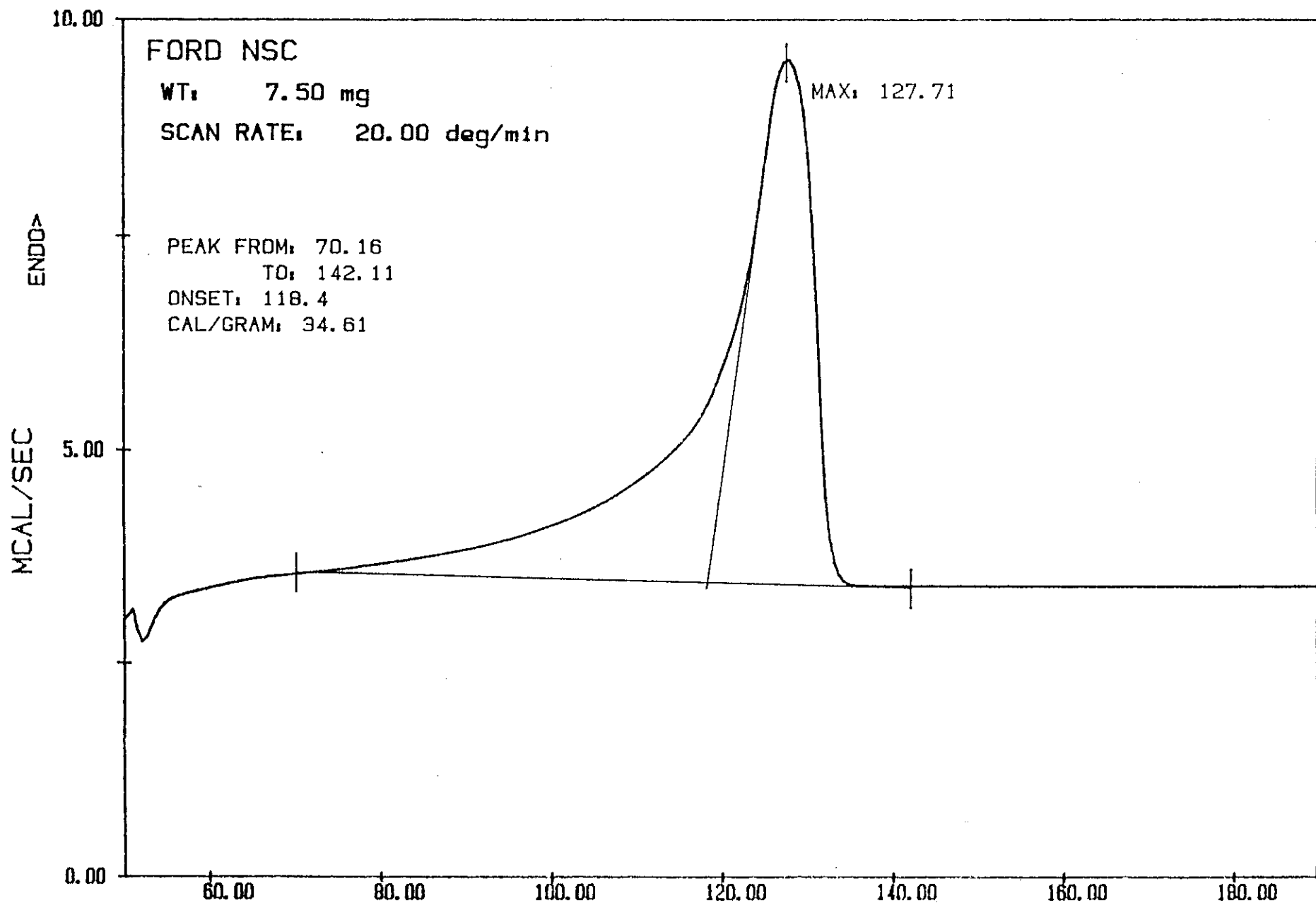
ASTM D 276 "Standard Methods for Identification of Fibers in Textiles", American Society for Testing and Materials, Philadelphia, PA, 07.02, 1985, pp. 95-113.

APPENDIX A

ENDOTHERMS AND EXOTHERMS

NATIONAL SEAL GEOMEMBRANE (INITIAL)

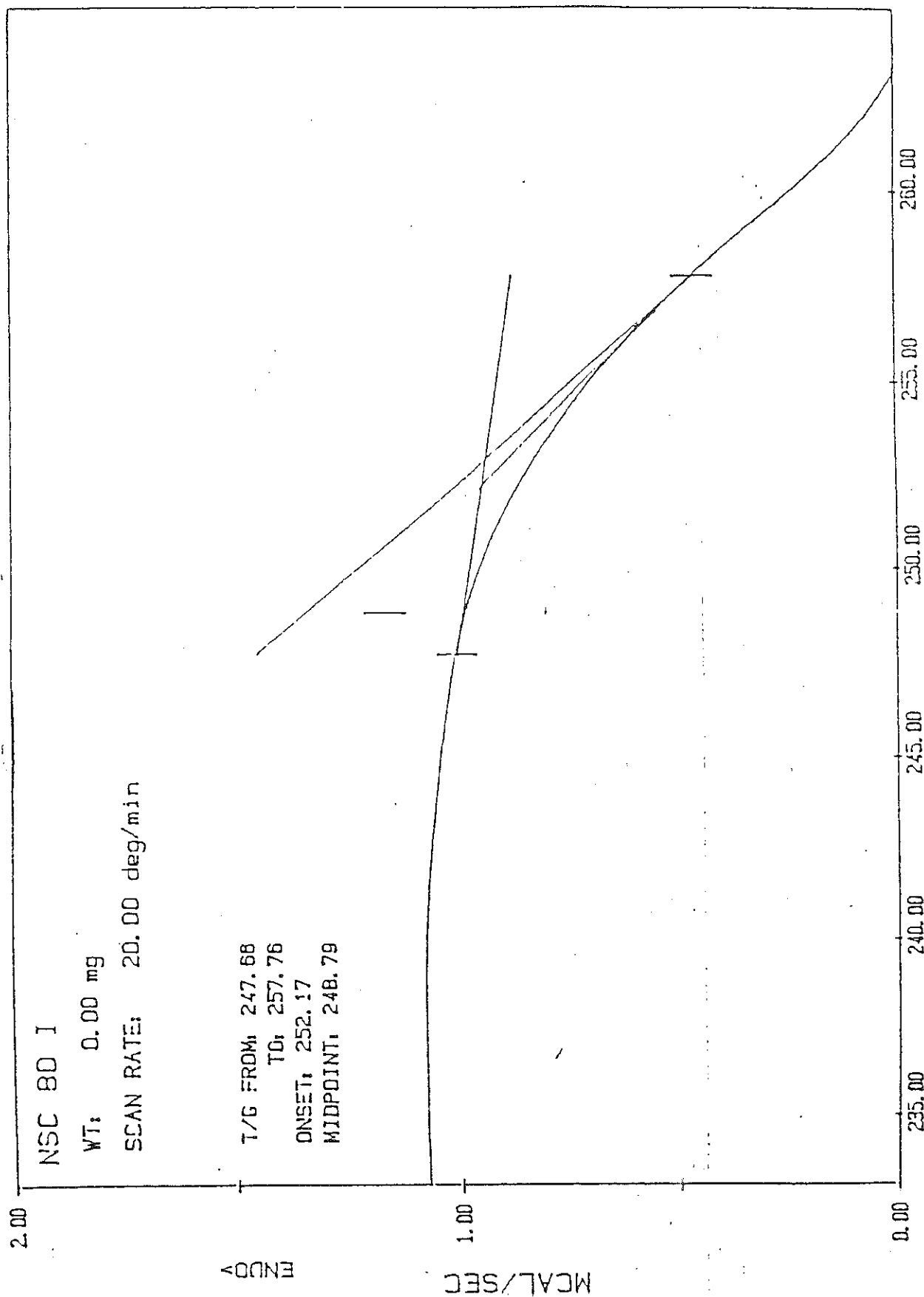




LGT FILE: FDNSC.D4

DSC

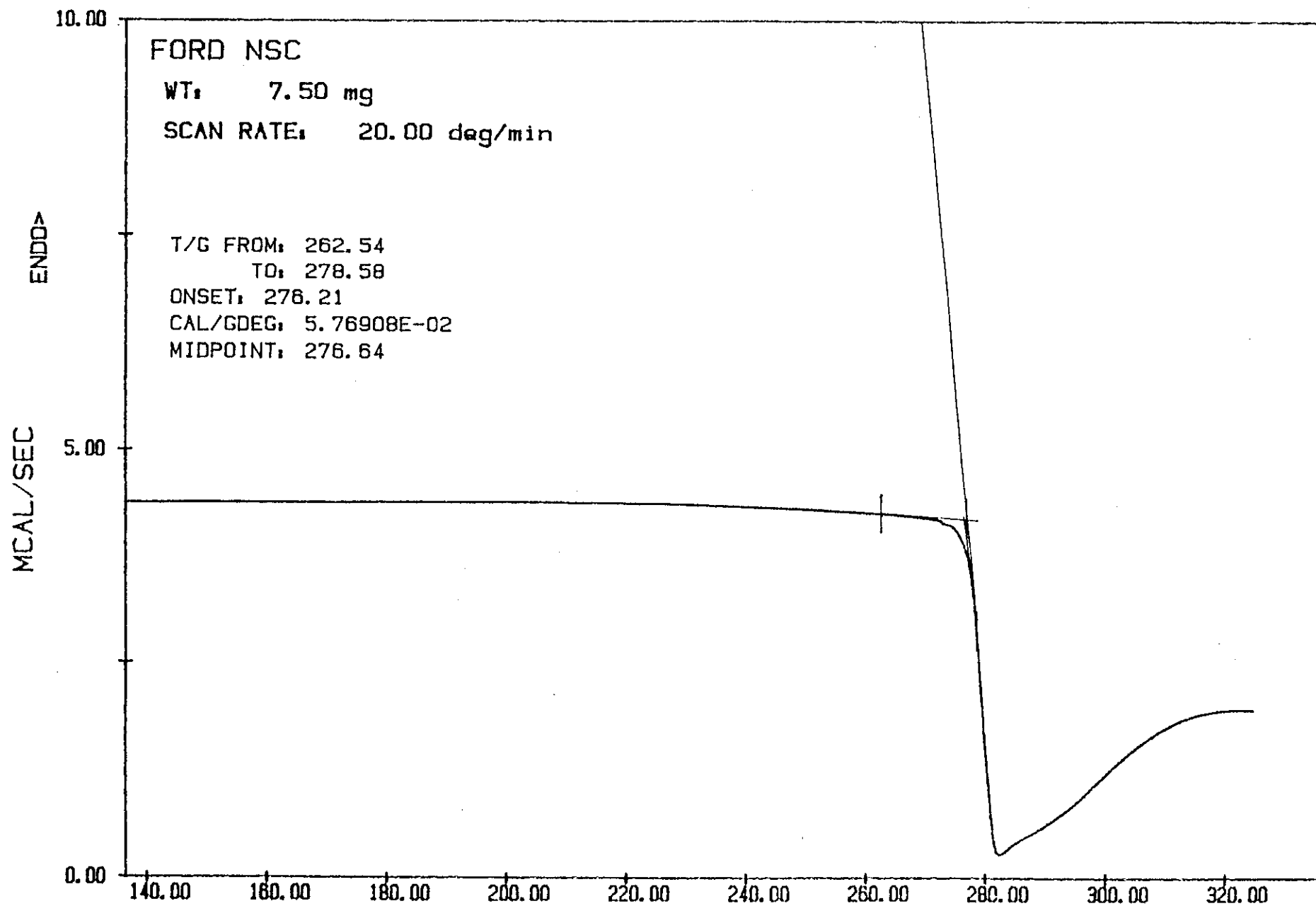
1 E: YY/MM/DD TIME: 00:37



DSC

FILE: R5461.D4

DATE: 98/05/16 TIME: 10:23



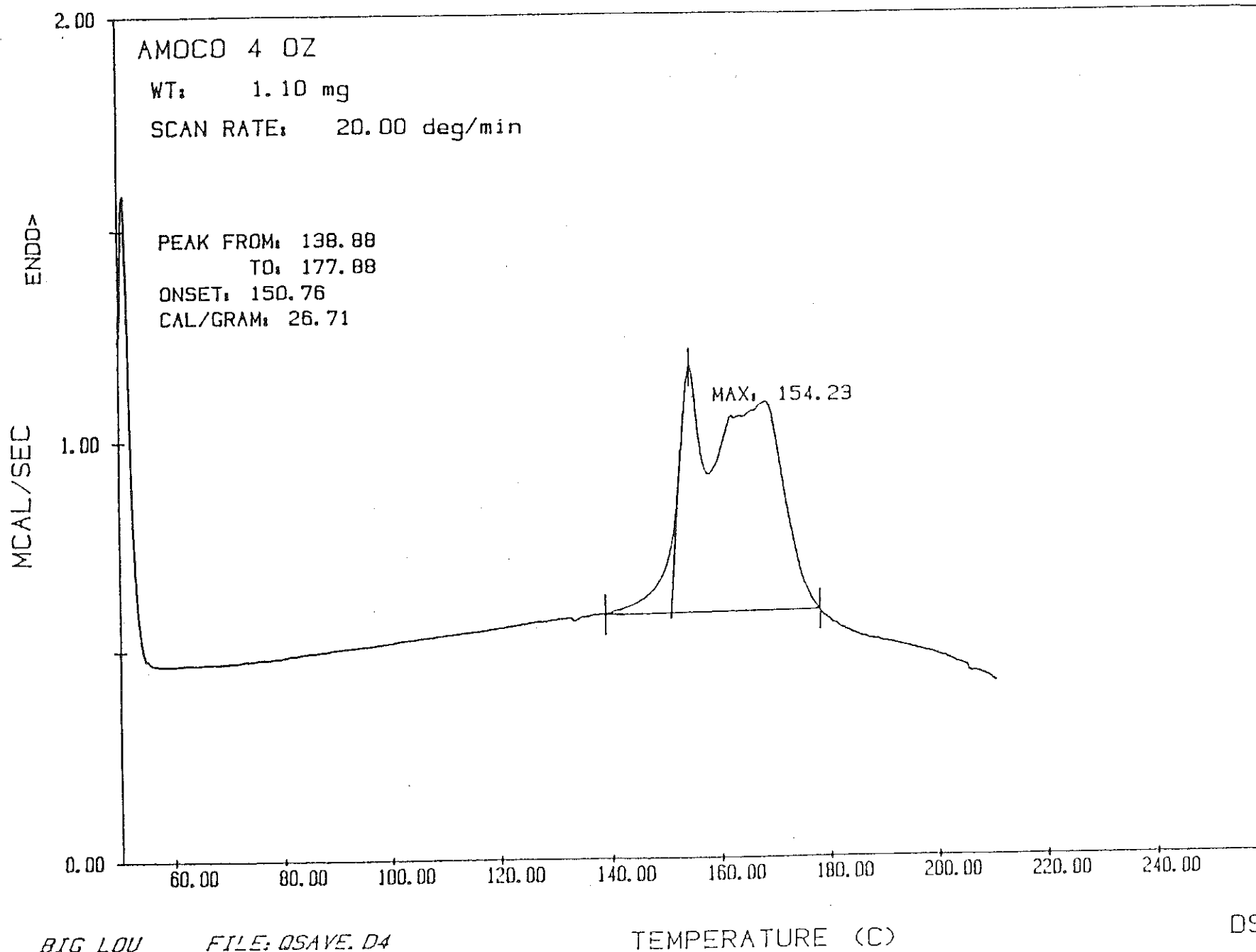
LGT FILE: F0NSC.D4

TEMPERATURE (C)

DSC

DATE: YY/MM/DD TIME: 00:37

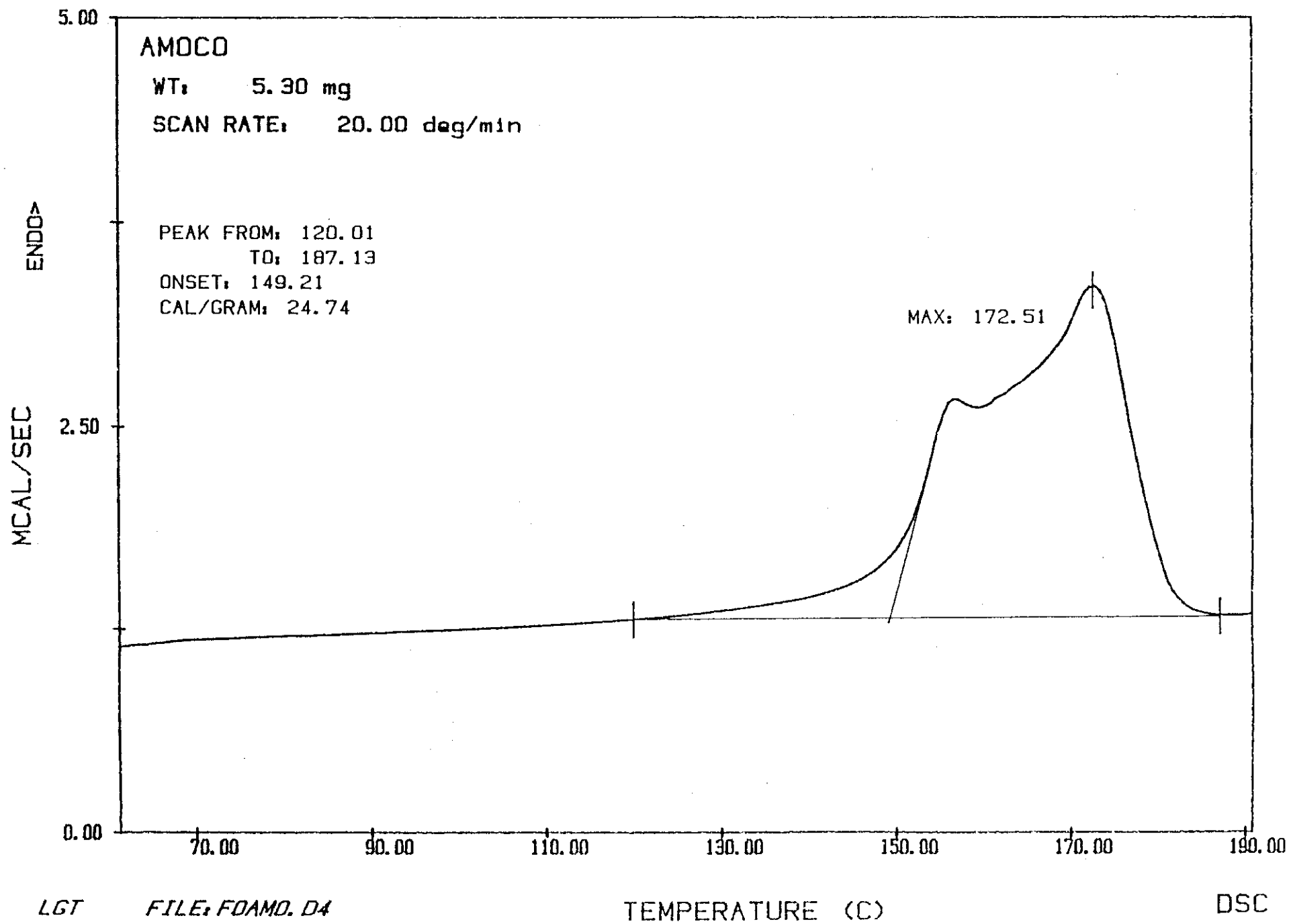
AMOCO 4 GEOTEXTILE (INITIAL)



BIG LOU FILE: QSAVE.D4

DATE: YY/MM/DD TIME: 00:33

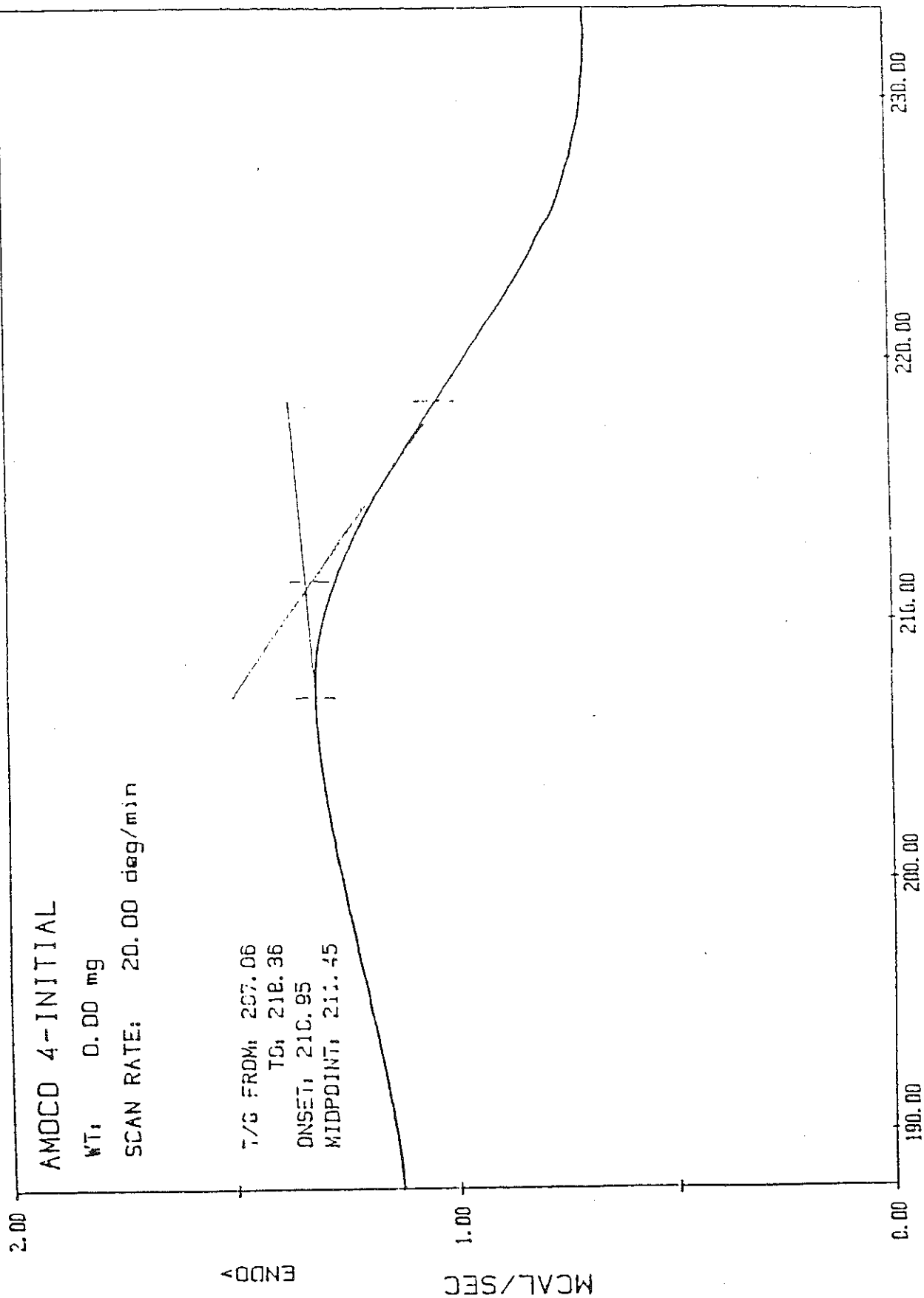
PERKIN-ELMER Thermal Analyst



LGT FILE: FDAMD.D4

DATE: YY/MM/DD TIME: 00:09

AMOCO 4 OZ GEOTEXTILE (INITIAL)

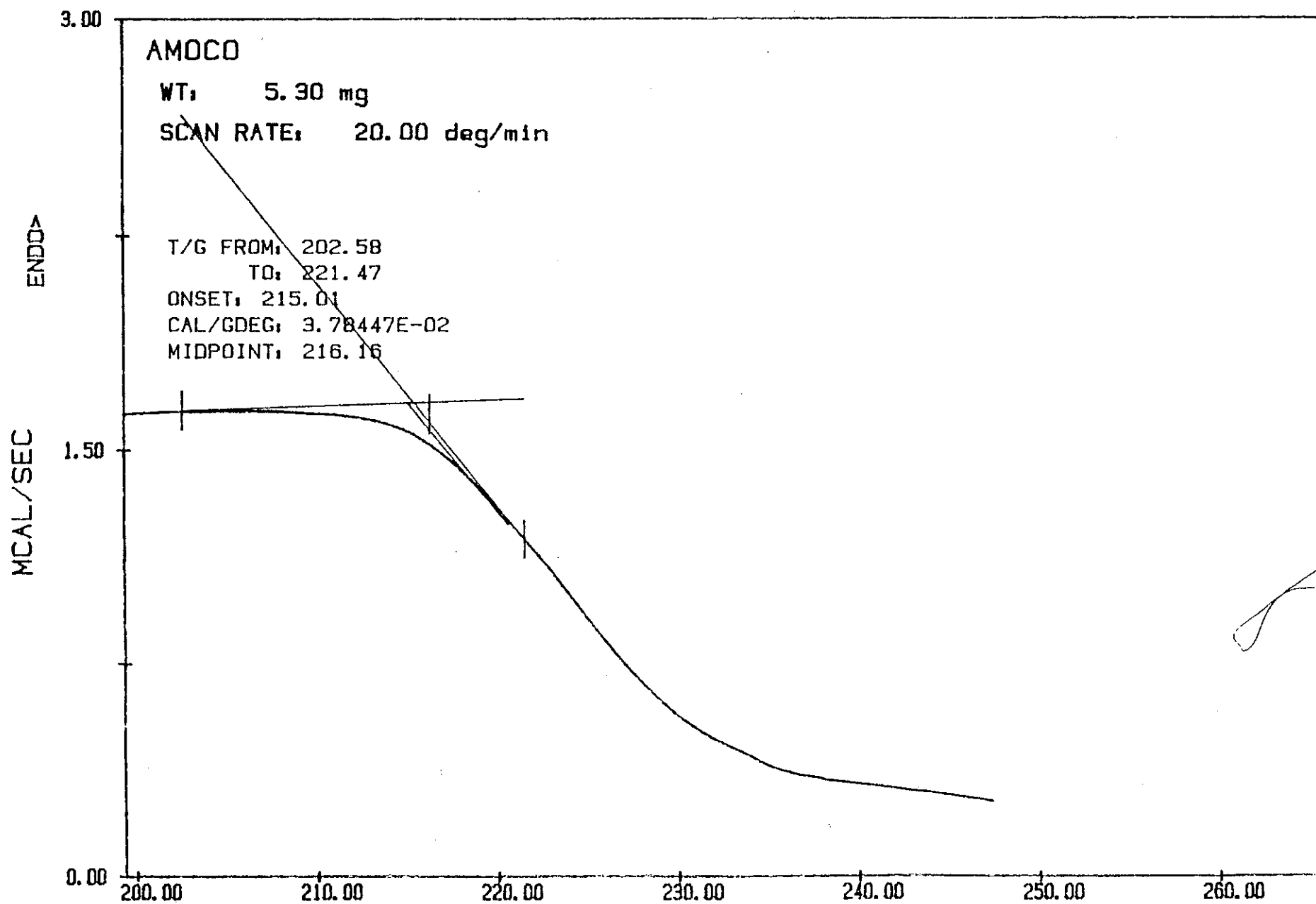


DSC

TEMPERATURE (C)

FILE: 54812.D4

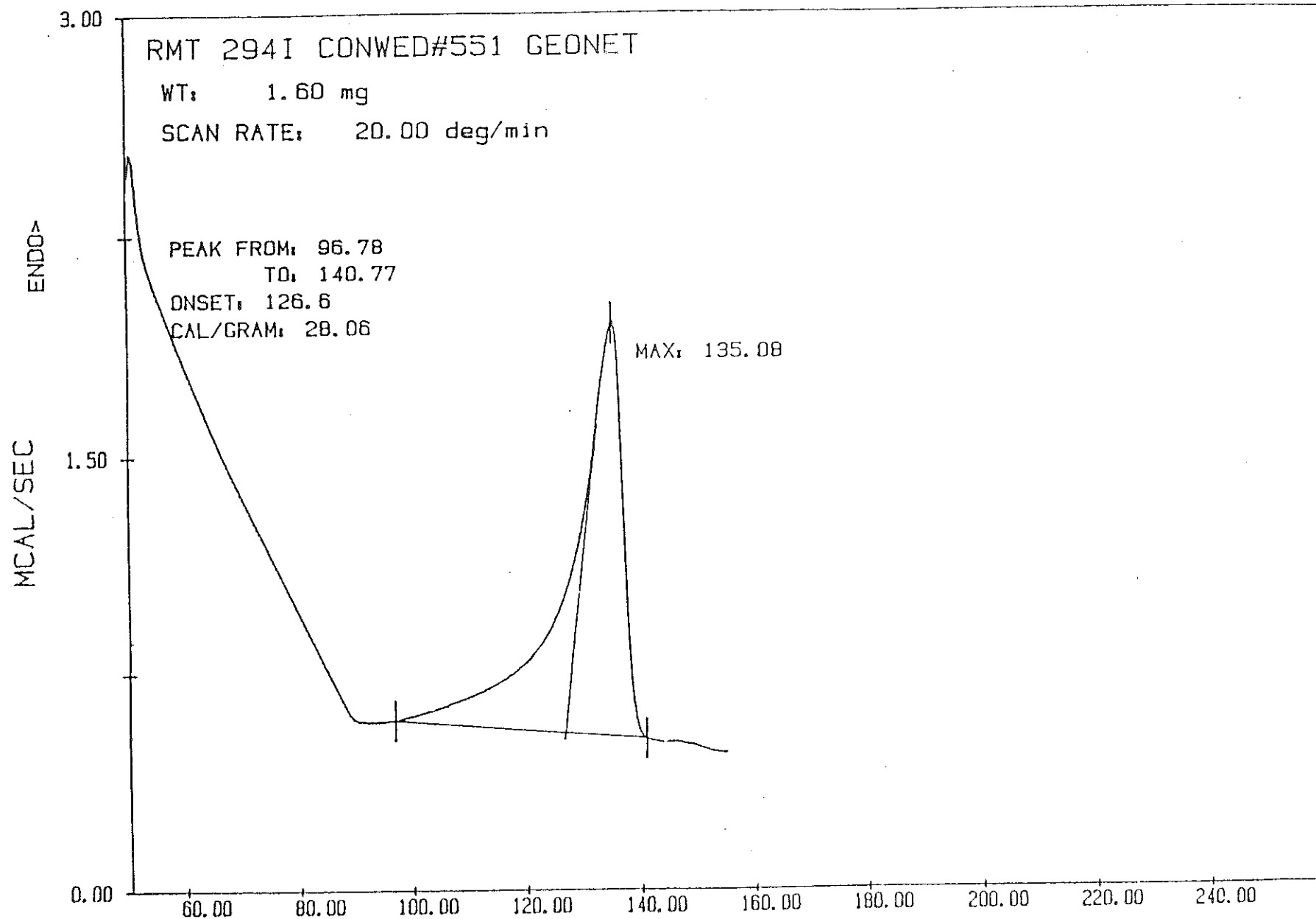
DATE: YY/MM/DD TIME: 05:25



LGT FILE: FOAMD.D4

FILE: YY/MM/DD TIME: 00:09

CONWED GEONET (INITIAL)

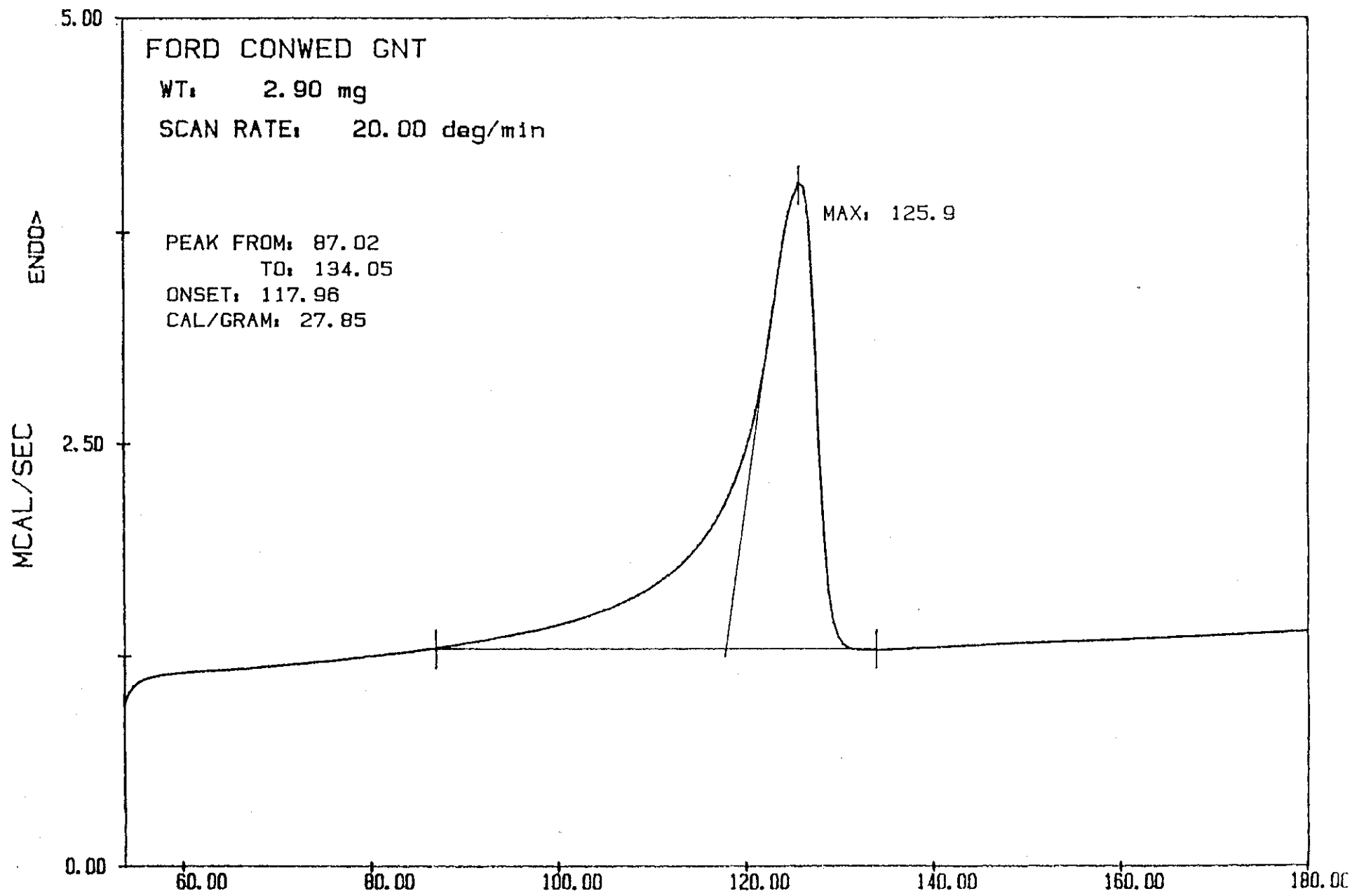


G. H. FILE: QSAVE.D4

TEMPERATURE (C)

JSC

DATE: 98/04/29 TIME: 17:21



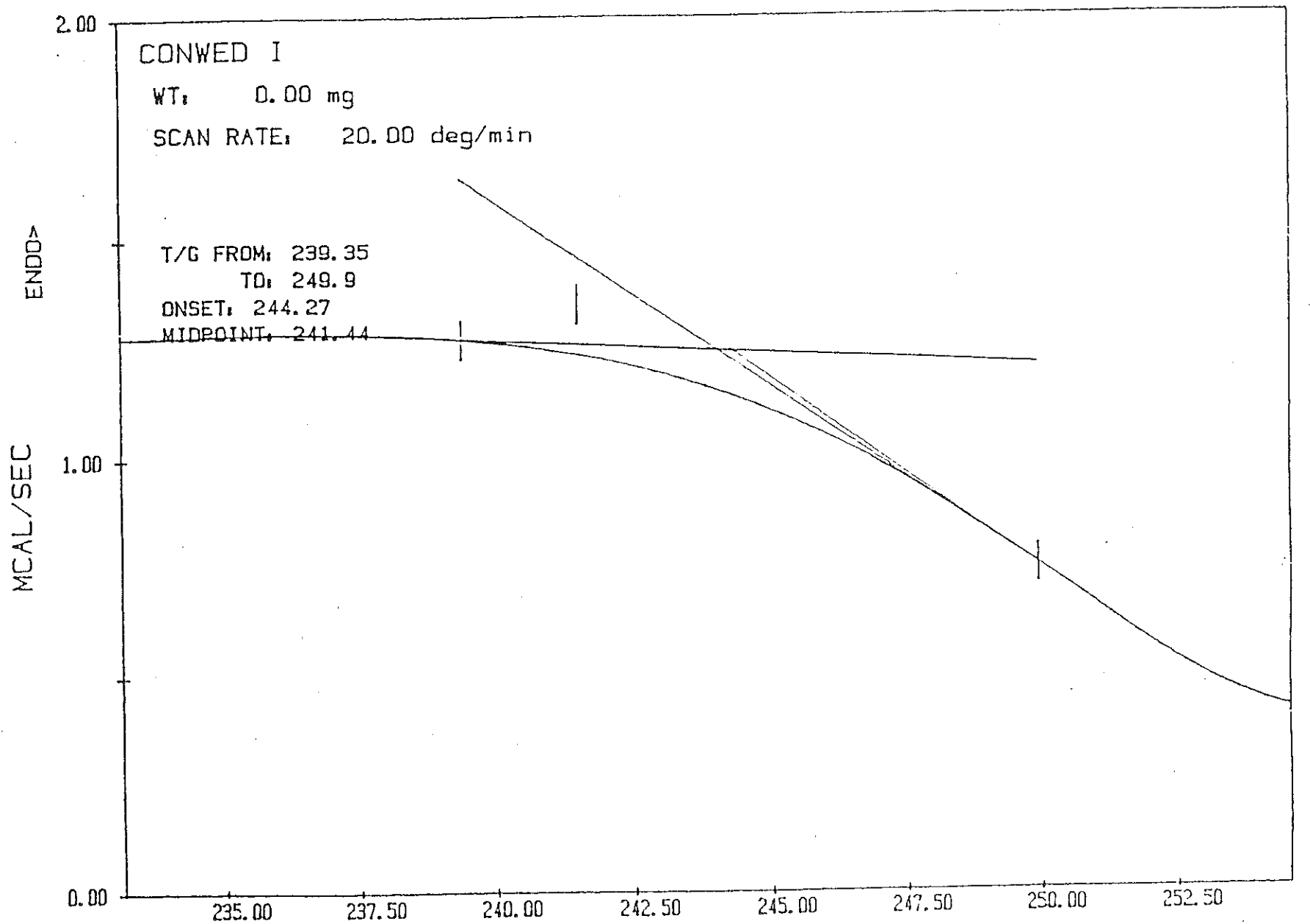
LGT FILE: FOCGN.D4

TEMPERATURE (C)

DSC

.E. YY/MM/DD TIME: 01.30

CONWED C ET (INITIAL)

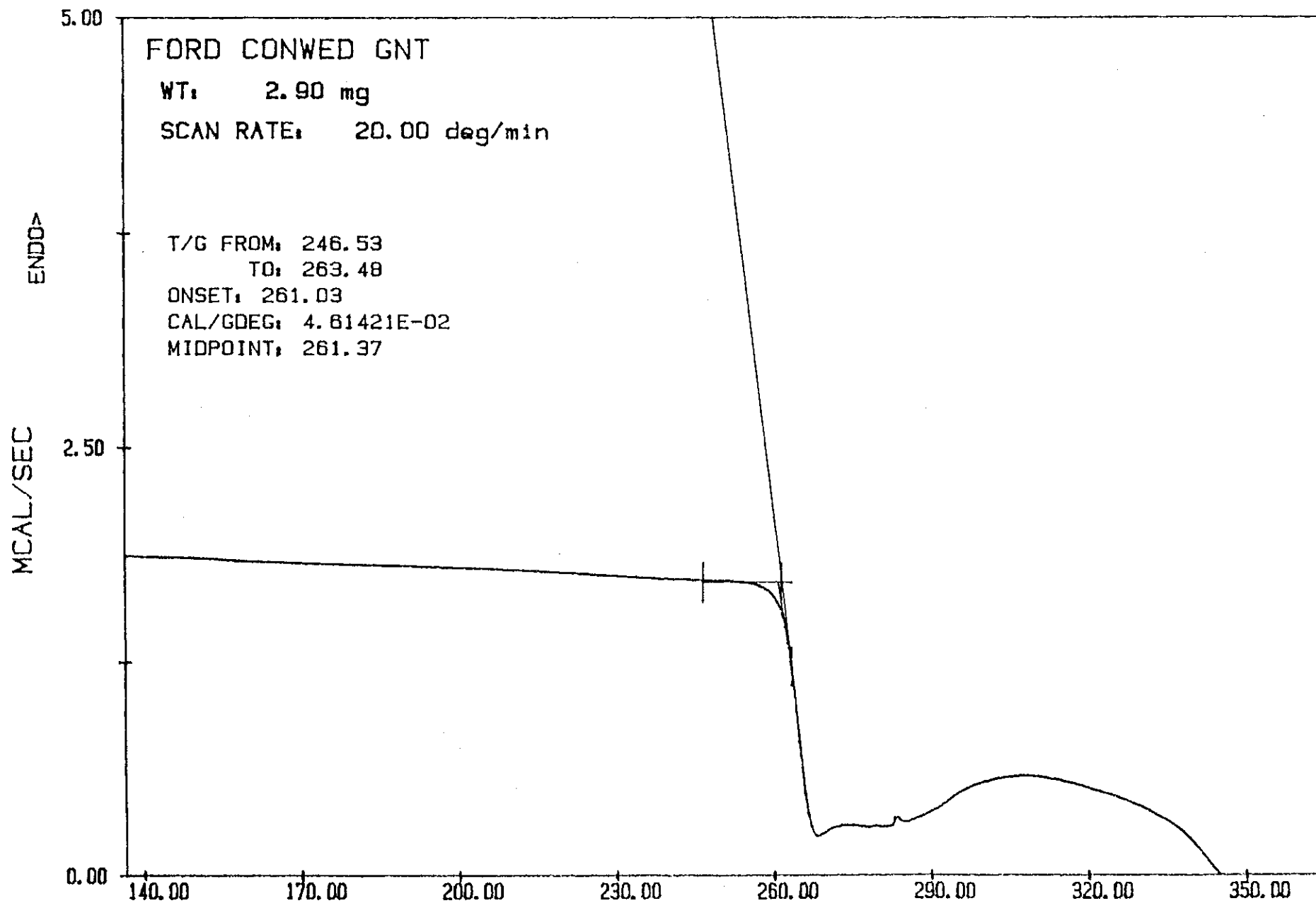


FILE: R5511.D4

TEMPERATURE (°C)

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DATE: 88/05/16 TIME: 11:22



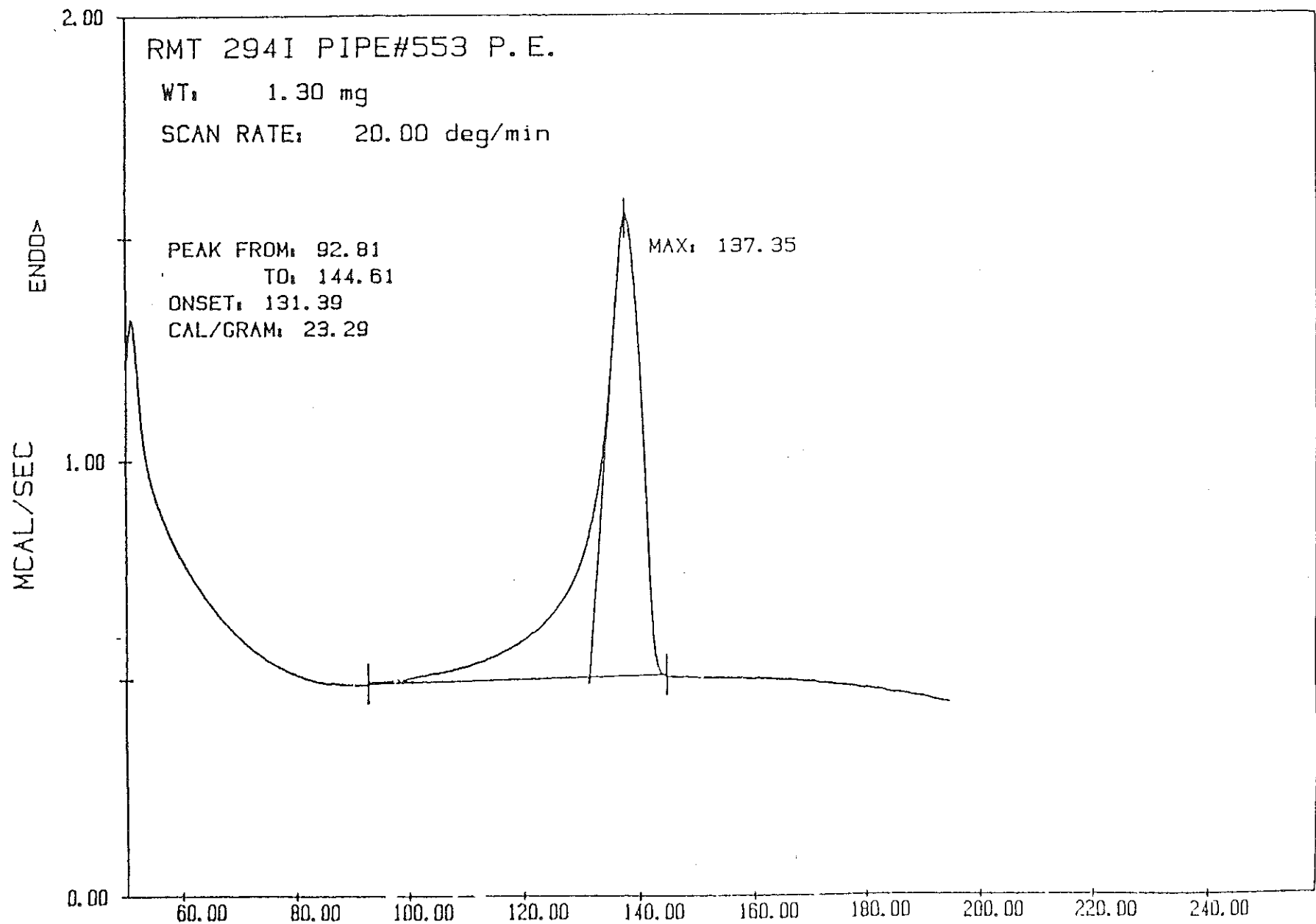
LGT FILE: FDCGN.D4

TEMPERATURE (C)

DSC

IE: YY/MM/DD TIME: 01:30

PIPE (INITIAL)

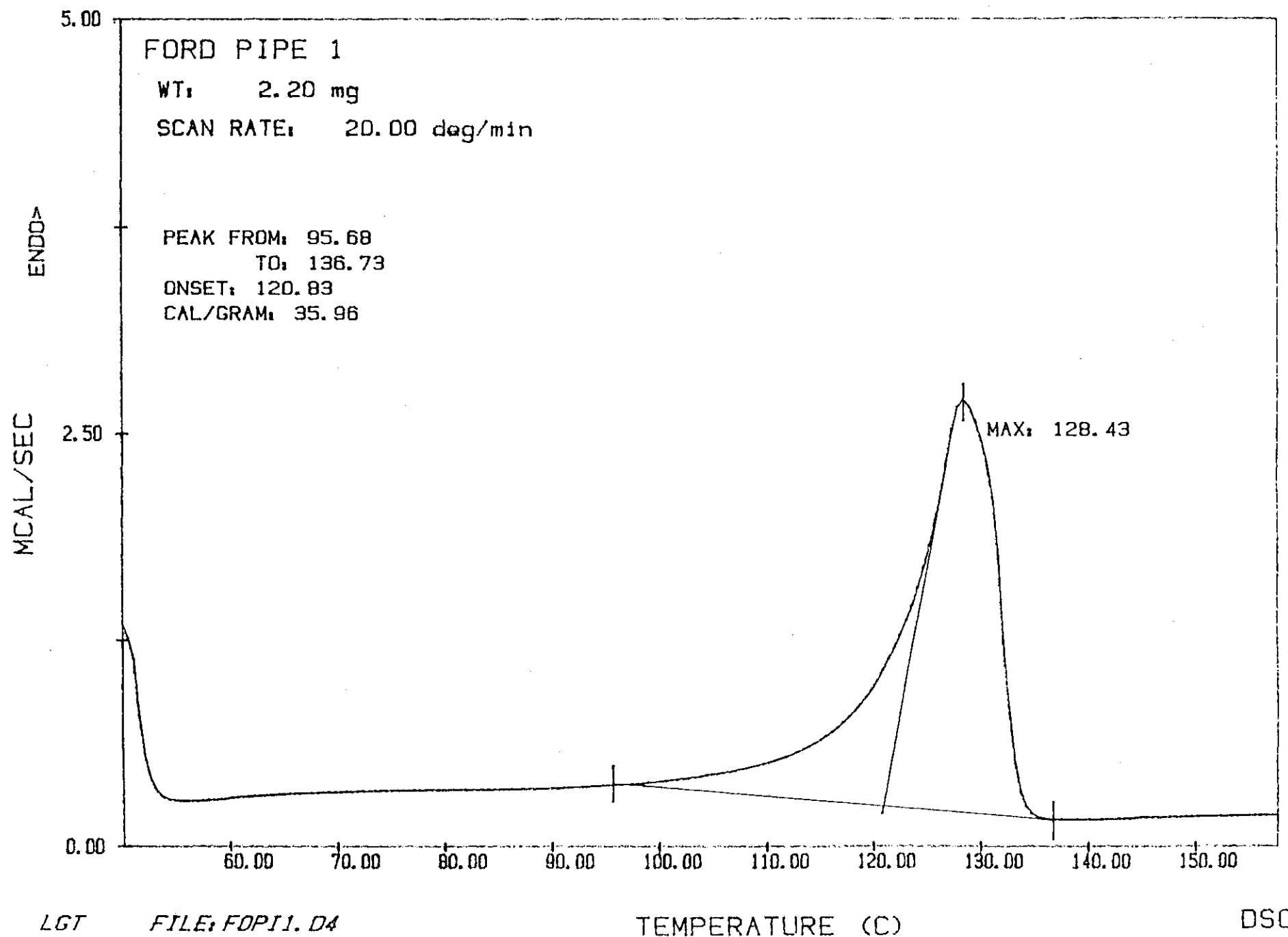


G. H. FILE: QSAVE.D4

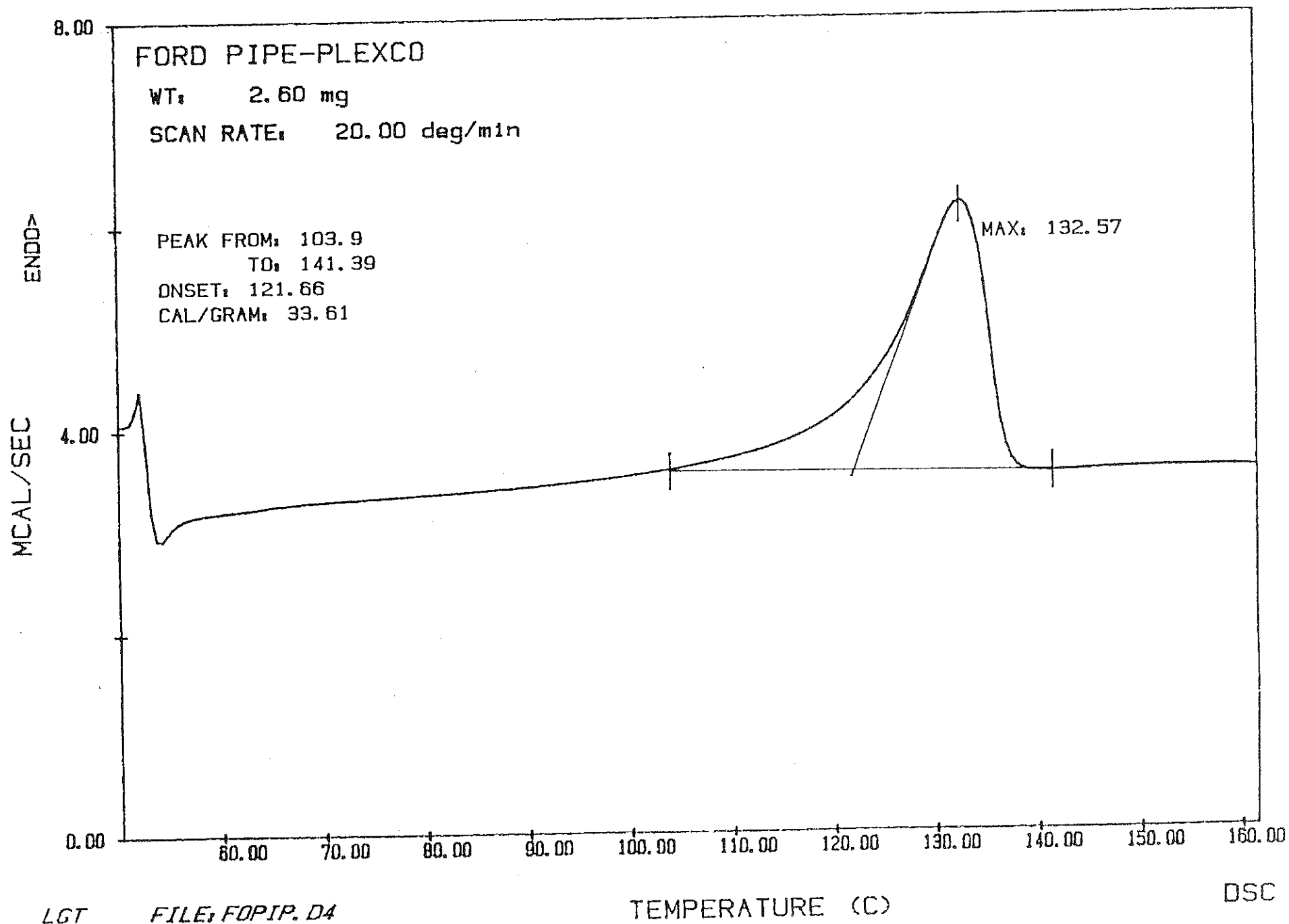
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DSC

DATE: 88/05/03 TIME: 15:07



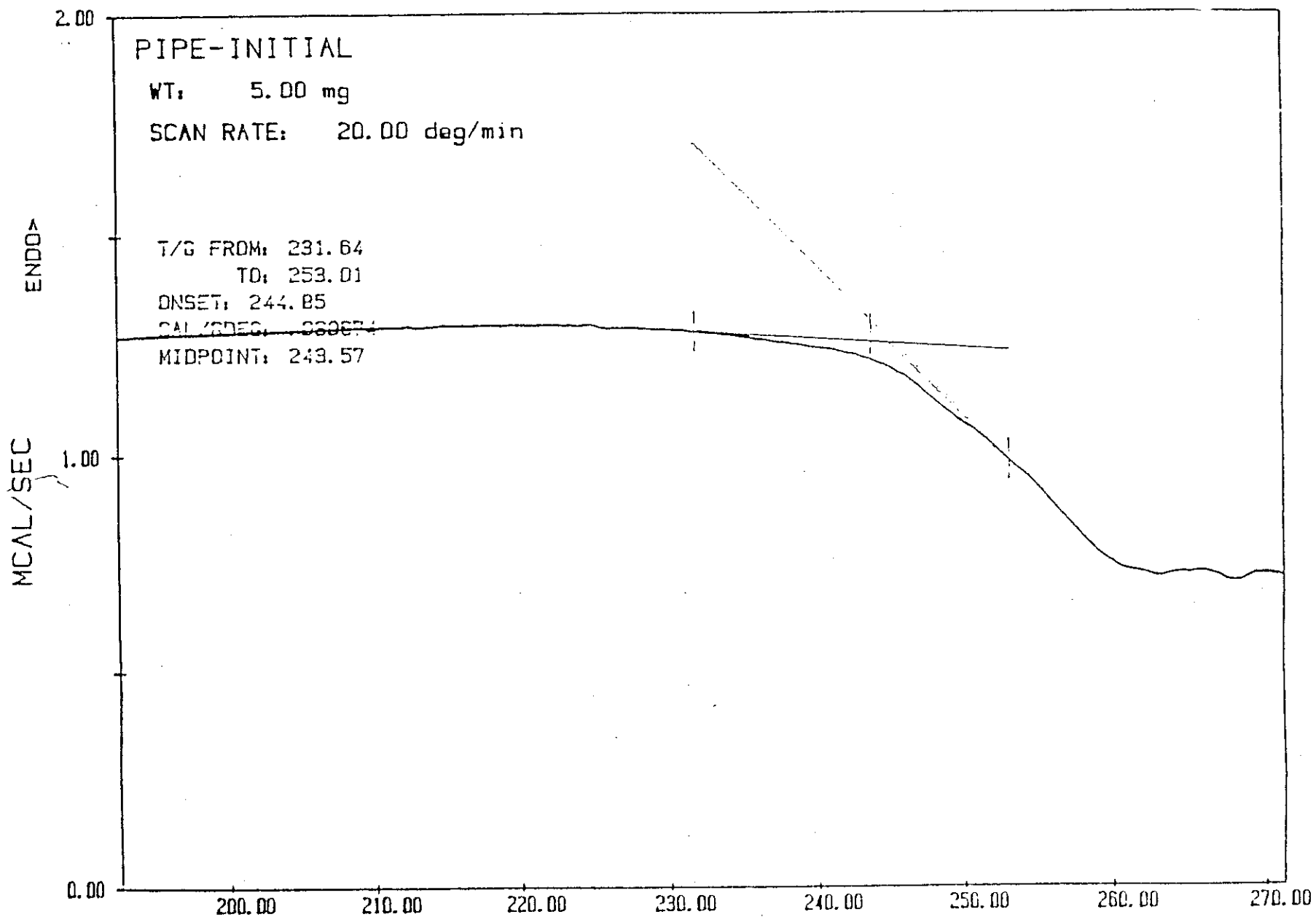
TE: YY/MM/DD TIME: 00:03



LGT FILE: FOPIP.D4

DATE: YY/MM/DD TIME: 00:04

PIPF INITIAL)

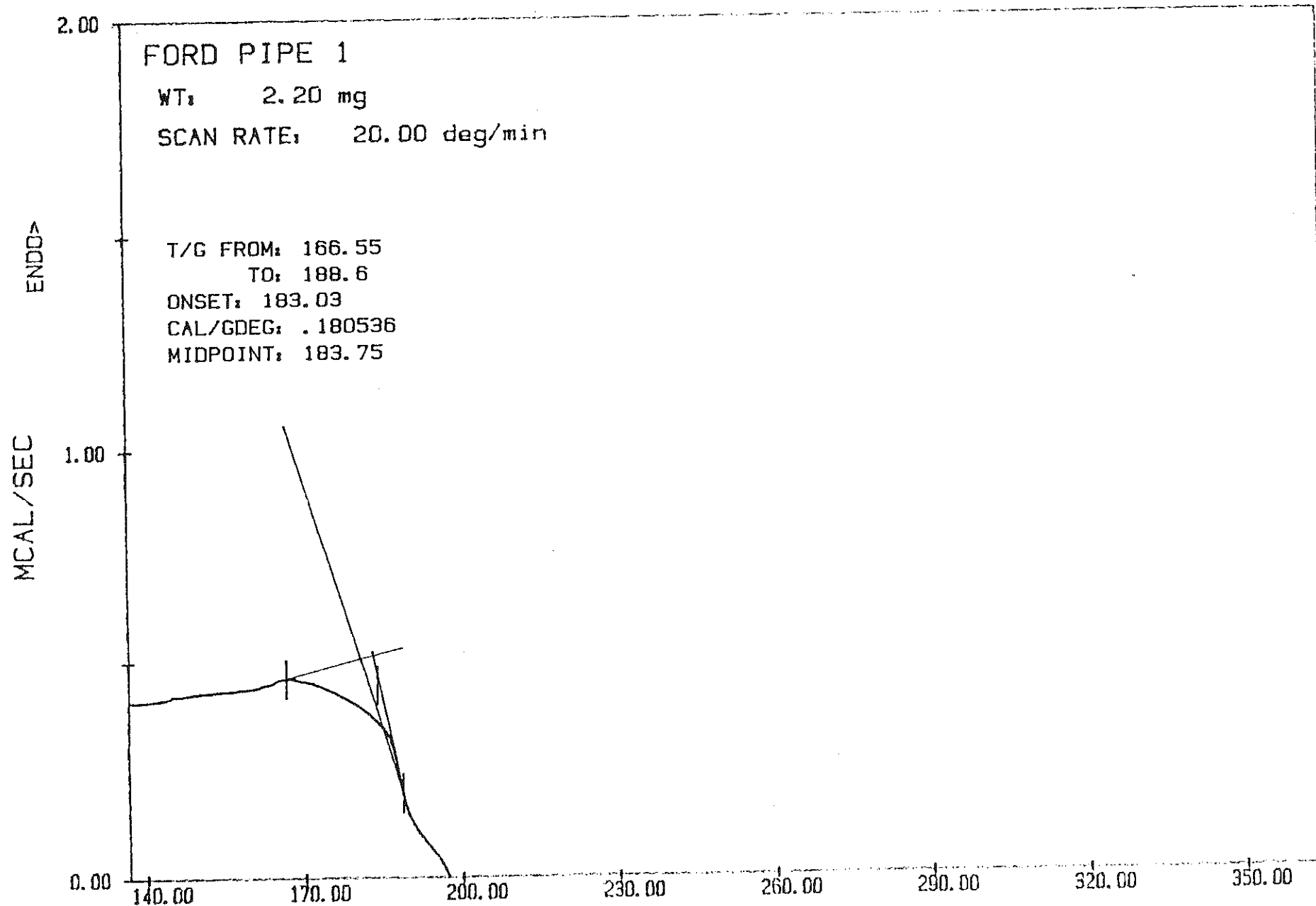


LNK FILE: 553XI.D4

TEMPERATURE (C)

DSC

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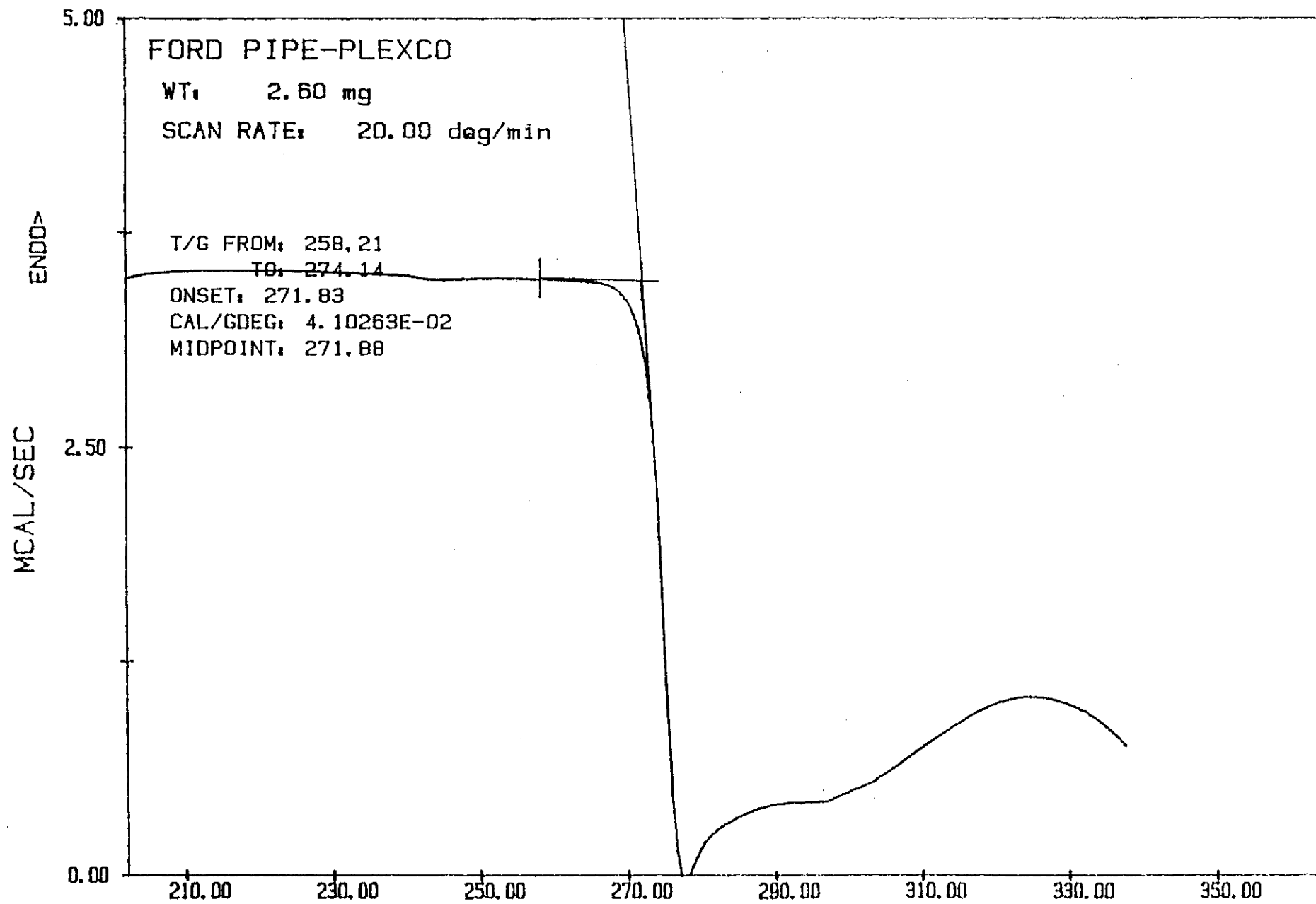


LGT FILE: F0PI1.D4

TEMPERATURE (C)

DSC

DATE: YY/MM/DD TIME: 00:03



LGT FILE: F0PIP.D4

TEMPERATURE (C)

DSC

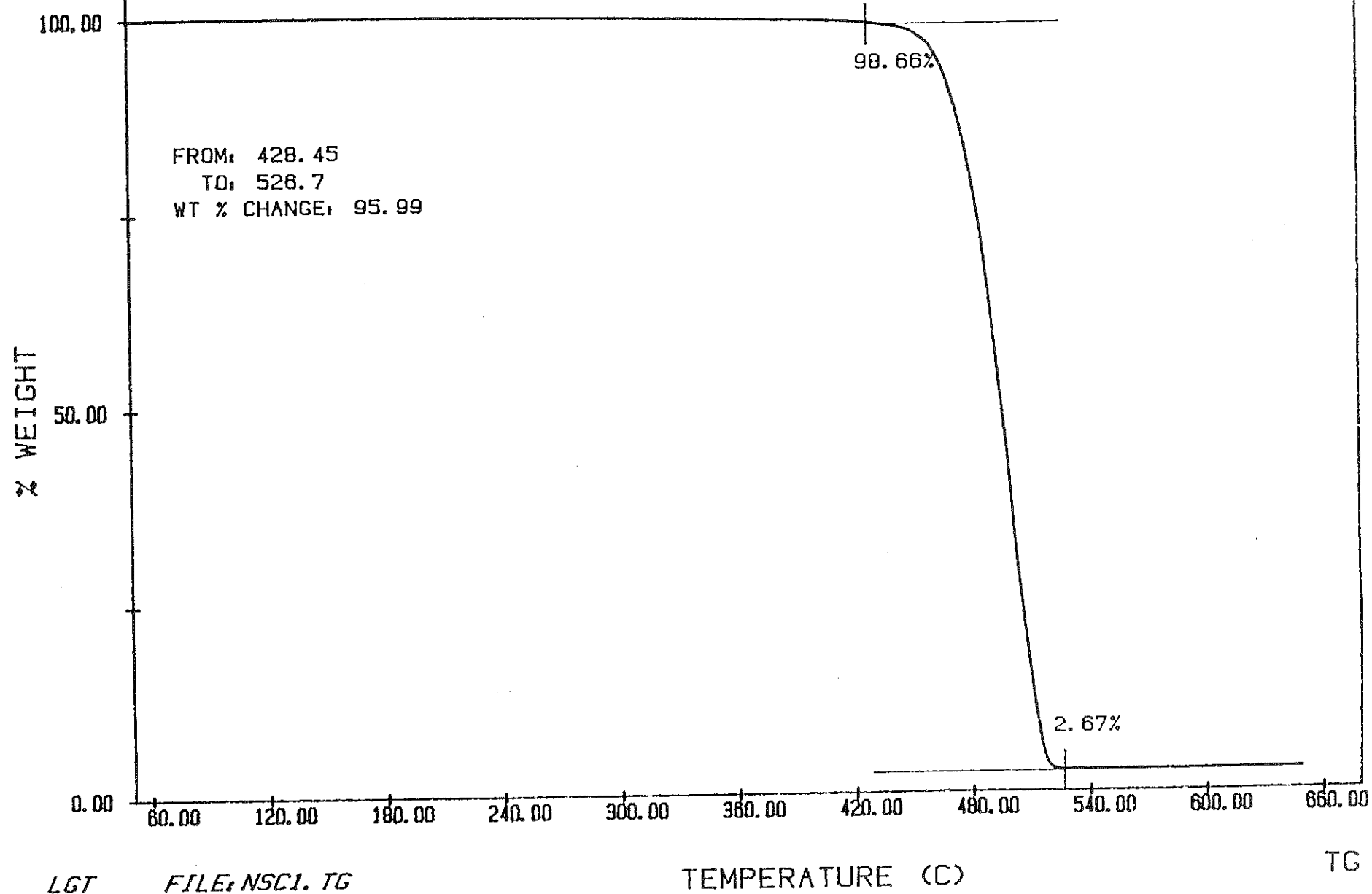
TE: YY/MM/DD TIME: 00:04

APPENDIX B

WEIGHT LOSS DIAGRAMS

FORD-NSC GMB

WT: 13.3452 mg RATE: 40.00 deg/min



NATIONAL SEAL GEOMEMBRANE (INITIAL)

WT: 1.8127 mg RATE: 40.00 deg/min

NSCI

100.00

50.00

0.00

Z WEIGHT

101.71%

100%

3.96%

FROM: 285.79
TO: 466.86
WT % CHANGE: 1.71

FROM: 466.86
TO: 612.74
WT % CHANGE: 96.03

110.00 170.00 230.00 290.00 350.00 410.00 470.00 530.00 590.00 650.00

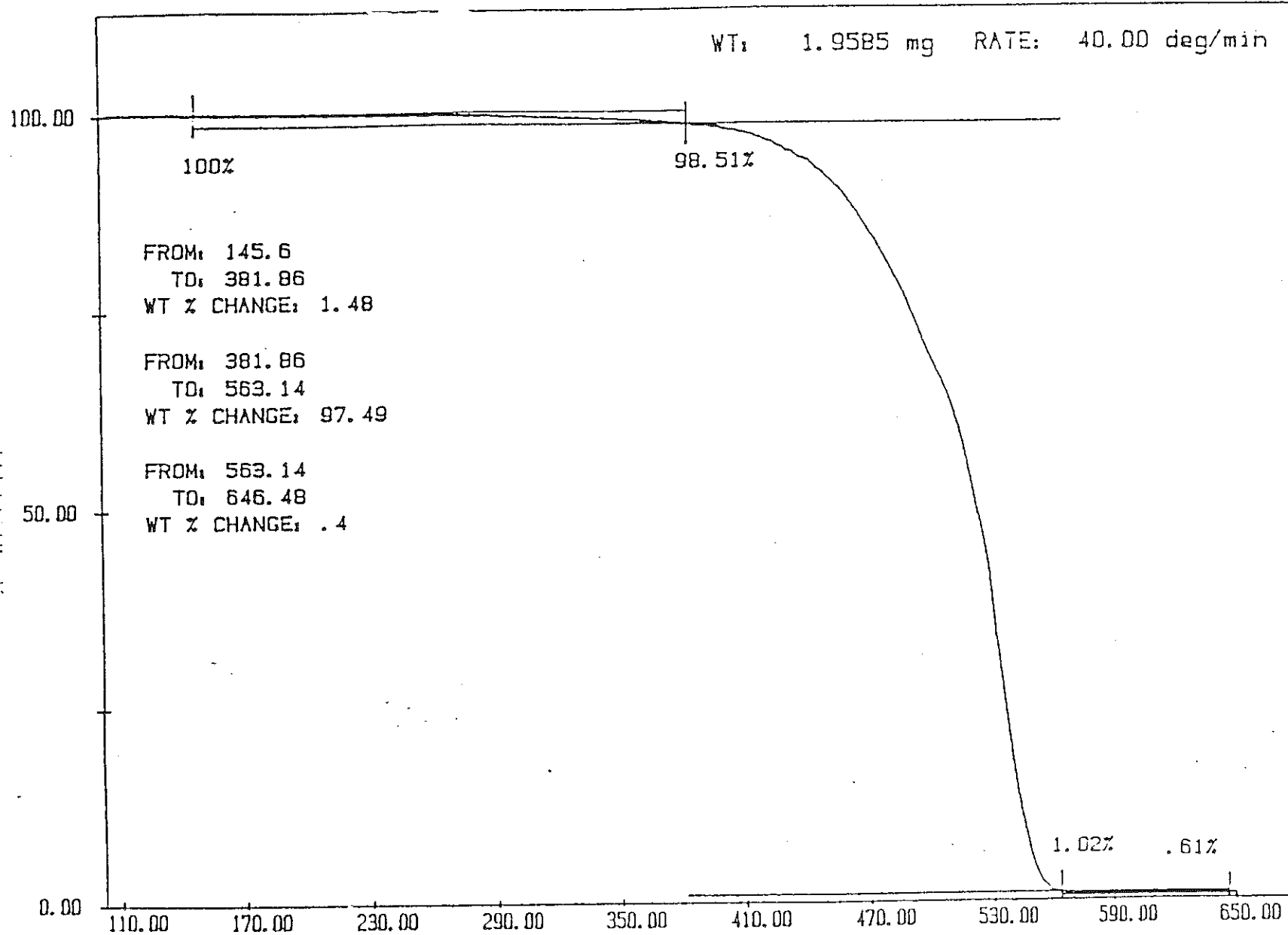
LOT: 5455770

TEMPERATURE (C)

TG

AMOCO 4 OZ GEOTEXTILE (INITIAL)

WT: 1.9585 mg RATE: 40.00 deg/min

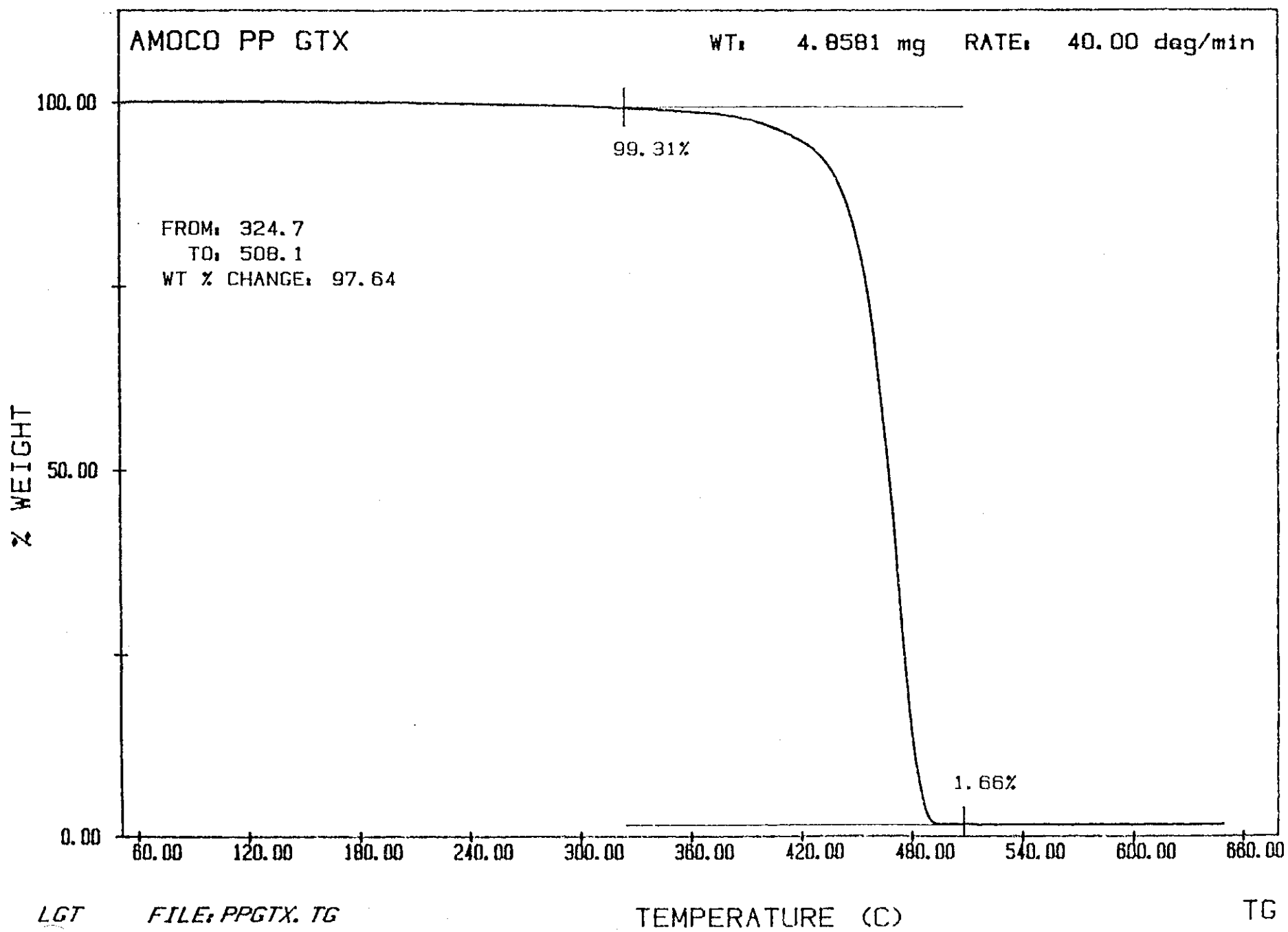


FILE: DSAVE.TG

TEMPERATURE (C)

TG

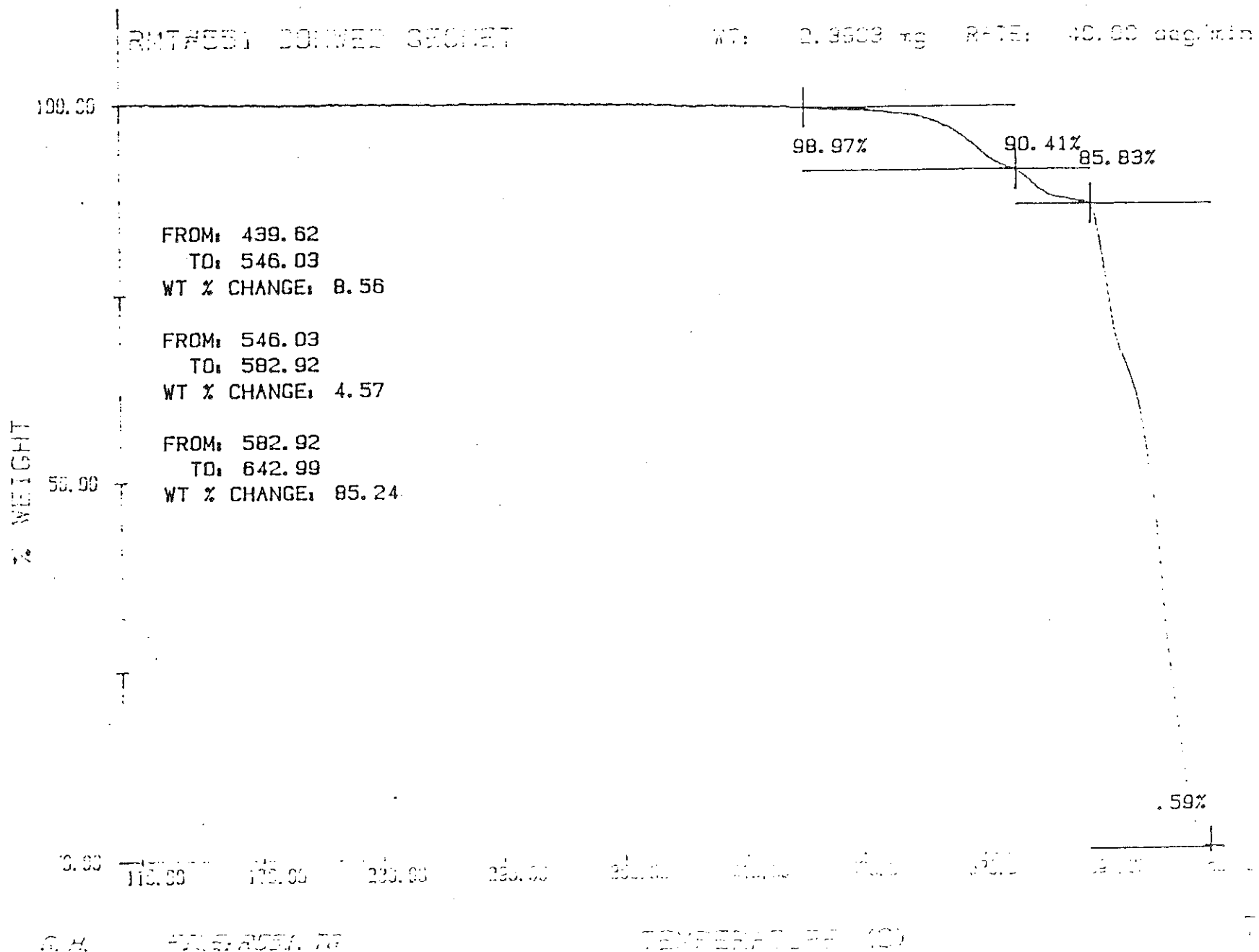
DATE: 8/05/13 TIME: 10:19



LGT FILE: PPGTX.TG

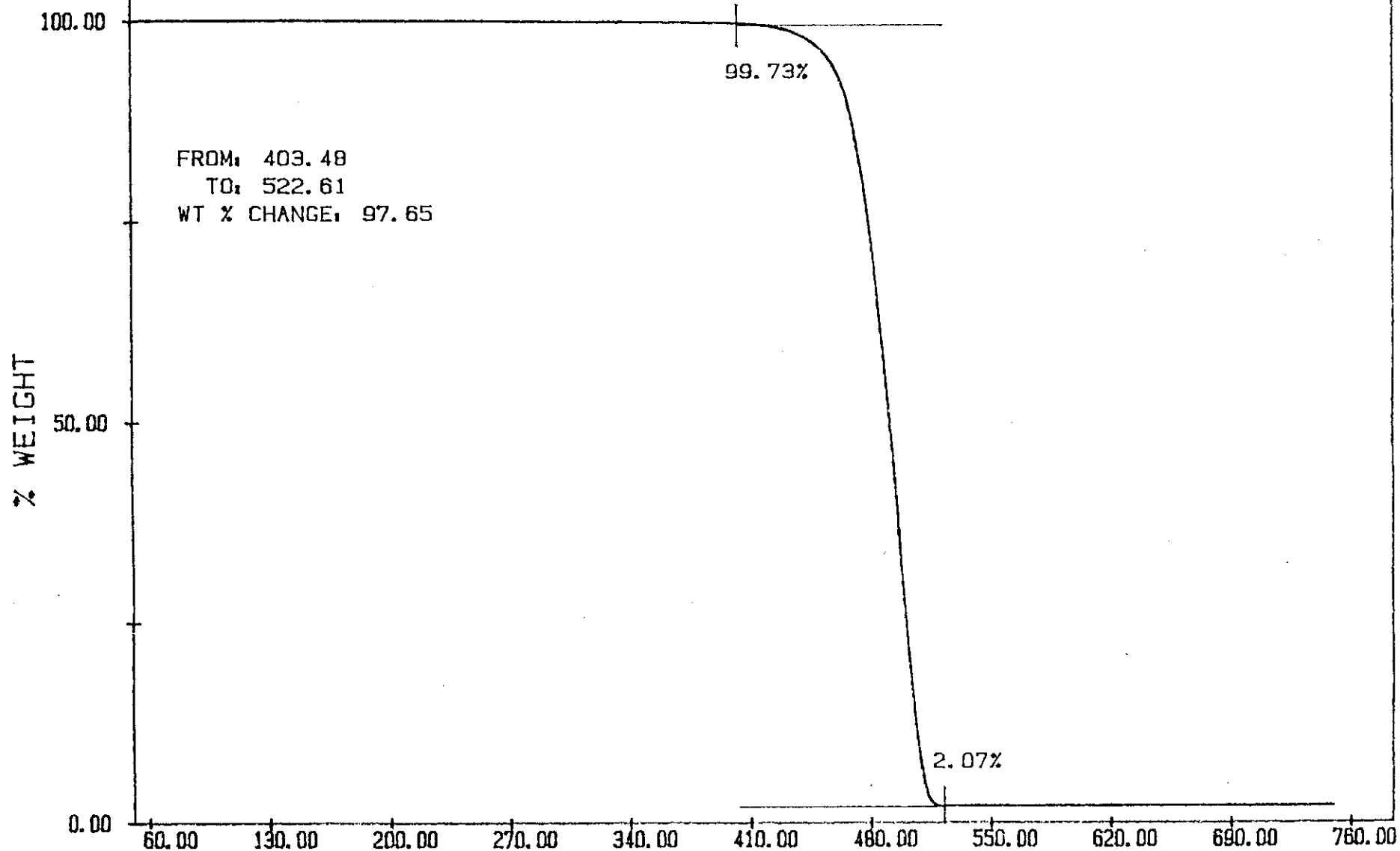
TE: YY/MM/DD TIME: 06.26

CONWED GEONET (INITIAL)



FORD CONWED GNT

WT: 7.4089 mg RATE: 40.00 deg/min



1 GT FILE: F0CON. TG

DATE: YY/MM/DD TIME: 01:42

PIPE (INITIAL)

RMT #5531 PIPE P.E.

WT: 1.7435 mg RATE: 40.00 deg/min

100.00

100.02%

88.25%

FROM: 357.64
TO: 545.57
WT % CHANGE: 11.77

FROM: 545.57
TO: 606.5
WT % CHANGE: 84.84

% WEIGHT

50.00

0.00

110.00 170.00 230.00 290.00 350.00 410.00 470.00 530.00 590.00 650.00

3.4%

G.H. FILE: R553.70

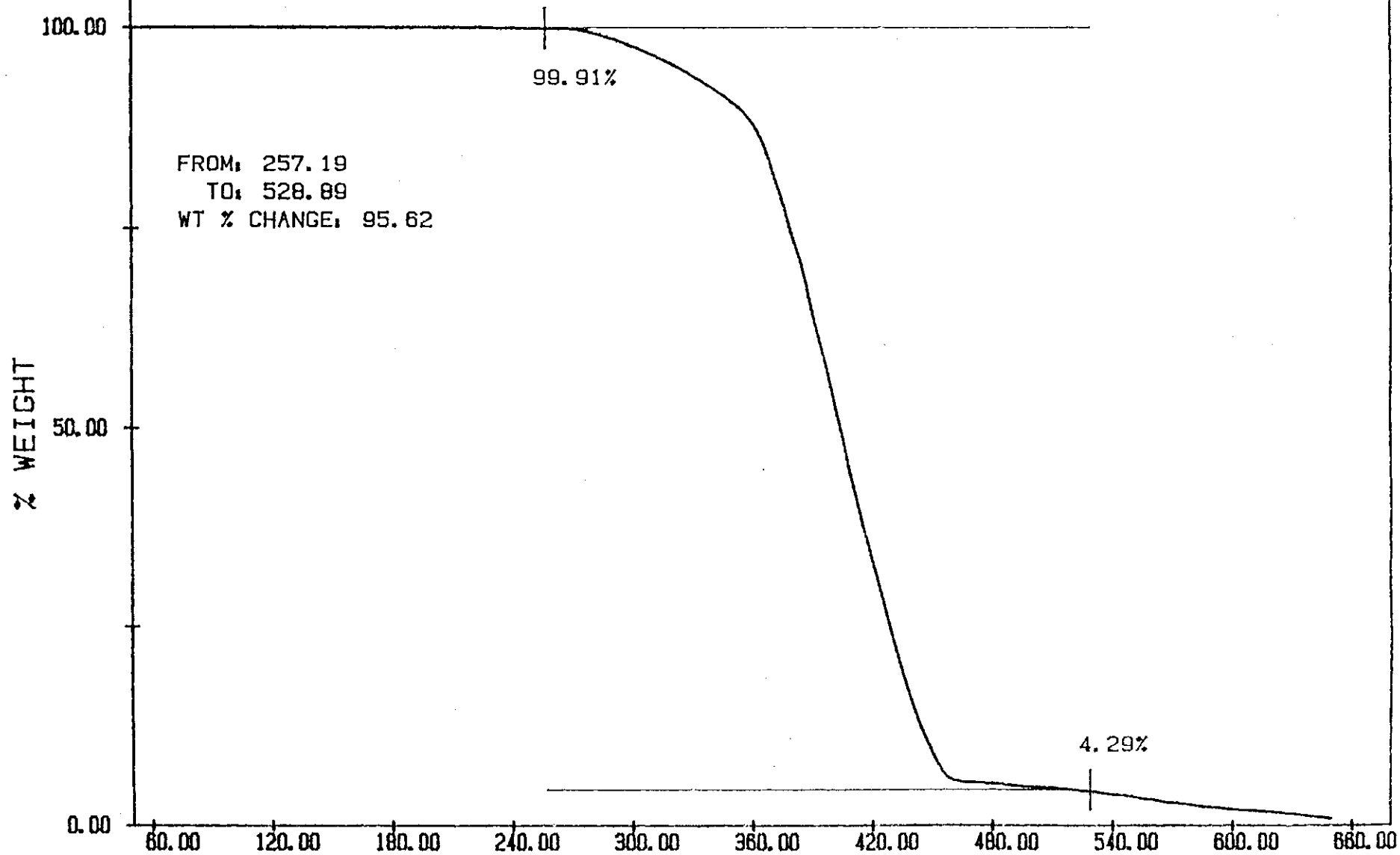
DATE: 88/05/19 TIME: 11:50

TEMPERATURE (C)

TO

FORD PIPE 1

WT: 4.8438 mg RATE: 40.00 deg/min



LGT FILE: FORD1. TG

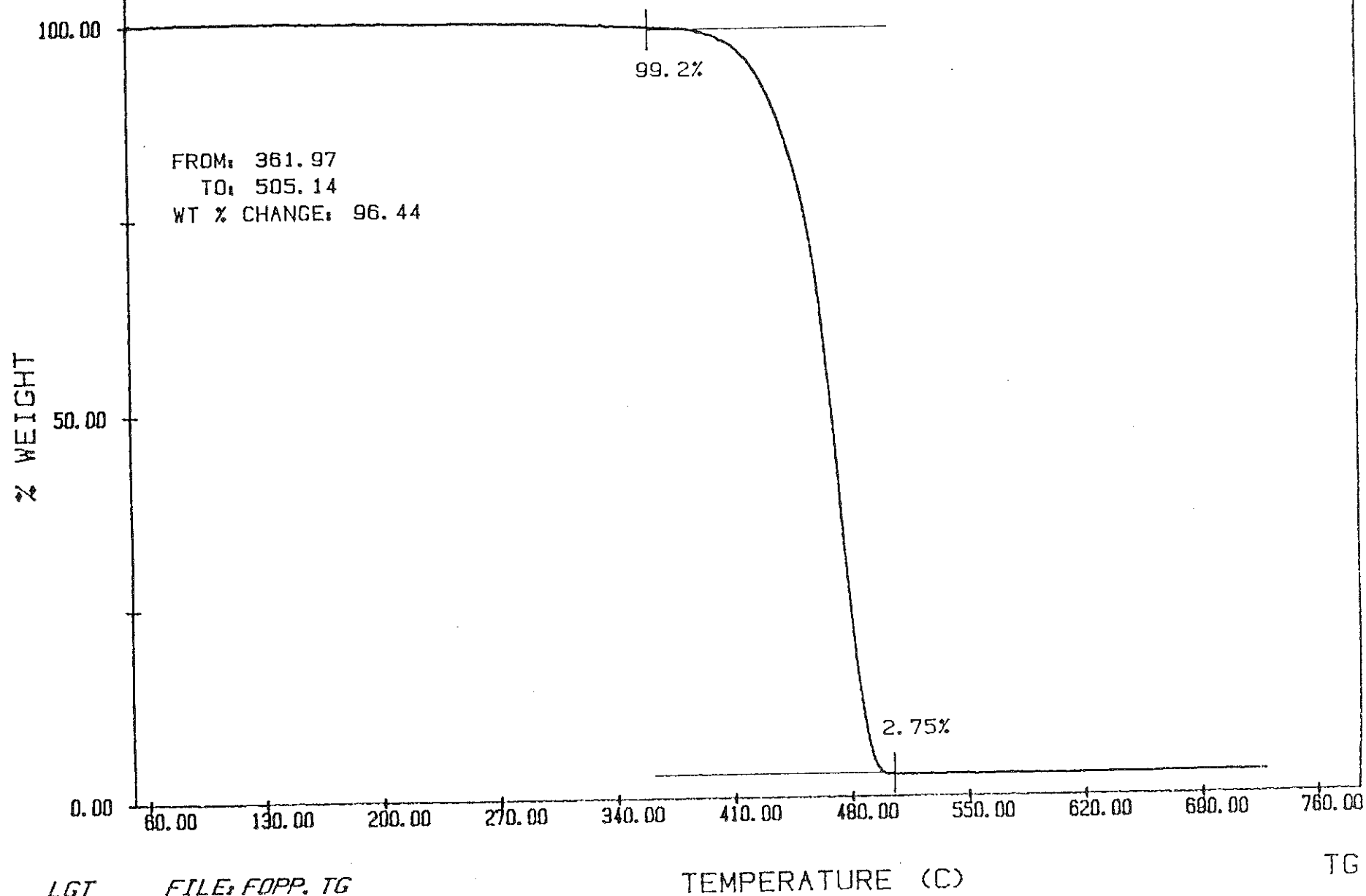
TEMPERATURE (C)

TG

DATE: YY/MM/DD TIME: 00:37

FORD PLEXCO PIPE

WT: 2.5336 mg RATE: 40.00 deg/min



LGT FILE: FOPP. TG

DATE: YY/MM/DD TIME: 00:58

D.1
SOIL LINER

JUNE 1993

SUMMARY OF PRECONSTRUCTION LABORATORY TESTING - CLAY SOILS
ALLEN PARK CLAY MINE - CELL 2
FORD MOTOR CO.

917-1203

CURVE NUMBER	SOURCE	SAMPLE NUMBER	NATURAL MOISTURE CONTENT (%)	ATTERBERG LIMITS			MODIFIED PROCTOR		USCS	TESTED BY	REMARKS
				LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTIC INDEX (%)	MAXIMUM DRY DENSITY (pcf)	OPTIMUM MOISTURE CONTENT (%)			
1	I-696	BLOCK 115	-	26	14	12	133.6	10.2	CL	NTH	
2	I-696	BAG 110	-	26	14	12	133.9	9.0	CL	NTH	
3	I-696	NO. 6	-	24	13	11	135.5	8.5	CL	GAI	
3A	I-696	NO. 7	9.3	25	13	12	135.5	9.0	CL	GAI	
4	I-696	NO. 2	9.2	18	10	8	134.0	8.8	CL	GAI	NO GRAIN SIZE PLOT
5	NATIVE	BLOCK 104	-	32	17	15	132.4	9.4	CL	NTH	
6	I-696	BLOCK 113	-	27	14	13	132.6	9.3	CL	NTH	
7	I-696	S-4	-	24	13	11	133.2	8.5	CL	GAI	
8	LONDON	3	-	-	-	-	132.4	9.4	CL	GAI	NO GRAIN SIZE PLOT
9	ANN ARBOR	S-5	13.7	24	13	11	133.5	8.5	CL	GAI	NO GRAIN SIZE PLOT
10	LONDON	P-1	9.2	18	10	8	122.3	12.7	CL	GAI	
11	LONDON	P-2	13.9	25	13	12	126.2	9.8	CL	GAI	
12	I-696	BAG 100	-	-	-	-	132.8	9.1	CL	NTH	NO GRAIN SIZE PLOT
13	LONDON	L-1	8.2	25	14	11	132.1	9.1	CL	GAI	
14	NATIVE	N-1	9.4	25	13	12	134.9	8.8	CL	GAI	
15	NATIVE	N-2	10.3	26	14	12	132.8	9.0	CL	GAI	
16	LONDON	PC-1	12.5	25	16	9	132.5	8.5	CL	GAI	
17	LONDON	PC-2	13.9	26	15	11	132.5	9.0	CL	GAI	
18	LONDON	PC-3	10.4	25	15	10	134.0	8.5	CL	GAI	
19	LONDON	PC-4	12.1	26	16	10	133.5	9.0	CL	GAI	
20	LONDON	PC-5	12.4	26	16	10	130.5	9.5	CL	GAI	
21	LONDON	PC-7	31.3	27	16	10	132.0	9.5	CL	GAI	
22	LONDON	SL-1	10.1	28	15	10	134.5	8.5	CL	GAI	
22A	LONDON	SL-2	9.2	25	14	11	130.5	9.5	CL	GAI	
23	LONDON	PC-9	12.0	25	14	10	133.0	9.0	CL	GAI	
24	LONDON	PC-10	11.8	26	15	11	129.0	11.0	CL	GAI	
25	LONDON	PC-11	11.3	26	15	11	133.0	9.5	CL	GAI	
26	I-696	PC-12	8.9	25	13	12	135.0	8.5	CL	GAI	
27	I-696	PC-13	9.0	26	15	11	135.0	9.0	CL	GAI	
28	LONDON	PC-14	16.8	27	16	11	131.5	9.0	CL	GAI	
29	LONDON	PC-15	13.1	26	16	10	132.0	10.0	CL	GAI	
30	LONDON	PC-16	14.1	26	16	10	130.5	10.5	CL	GAI	
31	LONDON	PC-21	-	27	15	12	132.0	9.5	CL	GAI	
32	LONDON	PC-18	12.8	26	16	10	133.5	9.5	CL	GAI	
33	LONDON	PC-19	-	27	15	12	132.5	9.0	CL	GAI	
34	LONDON	PC-20	-	26	16	10	131.5	9.0	CL	GAI	
35	LONDON	PC-17	12.8	26	16	10	132.0	9.5	CL	GAI	
36	LONDON	PC-22	-	27	15	12	131.5	10.0	CL	GAI	



NTH CONSULTANTS, LTD.

MOISTURE - DENSITY RELATIONS

PROJECT: Allen Park Clay Mine - Cell II

PROJECT NO.: 89365 OW

LOCATION: Allen Park, Michigan

DATE: 11/18/89

SUPPLIER/SOURCE: I-696 Excavation

TESTED BY: JN

SAMPLE LOCATION: Cell II; 3560 6970E, elevation 579.2

CHECKED BY: SG

METHOD OF COMPACTION: ASTM D-1557 Method A

LAB SAMPLE NO.: 7282

MOLD NO.: A VOLUME: 0.0330 CUBIC FEET MATERIAL DESIGNATION NO.: Block 115

SAMPLE DESCRIPTION: Gray SILTY CLAY with Some Sand and Trace of Gravel

MAXIMUM DRY DENSITY: 133.6 PCF

OPTIMUM MOISTURE CONTENT: 10.2 %

136

134

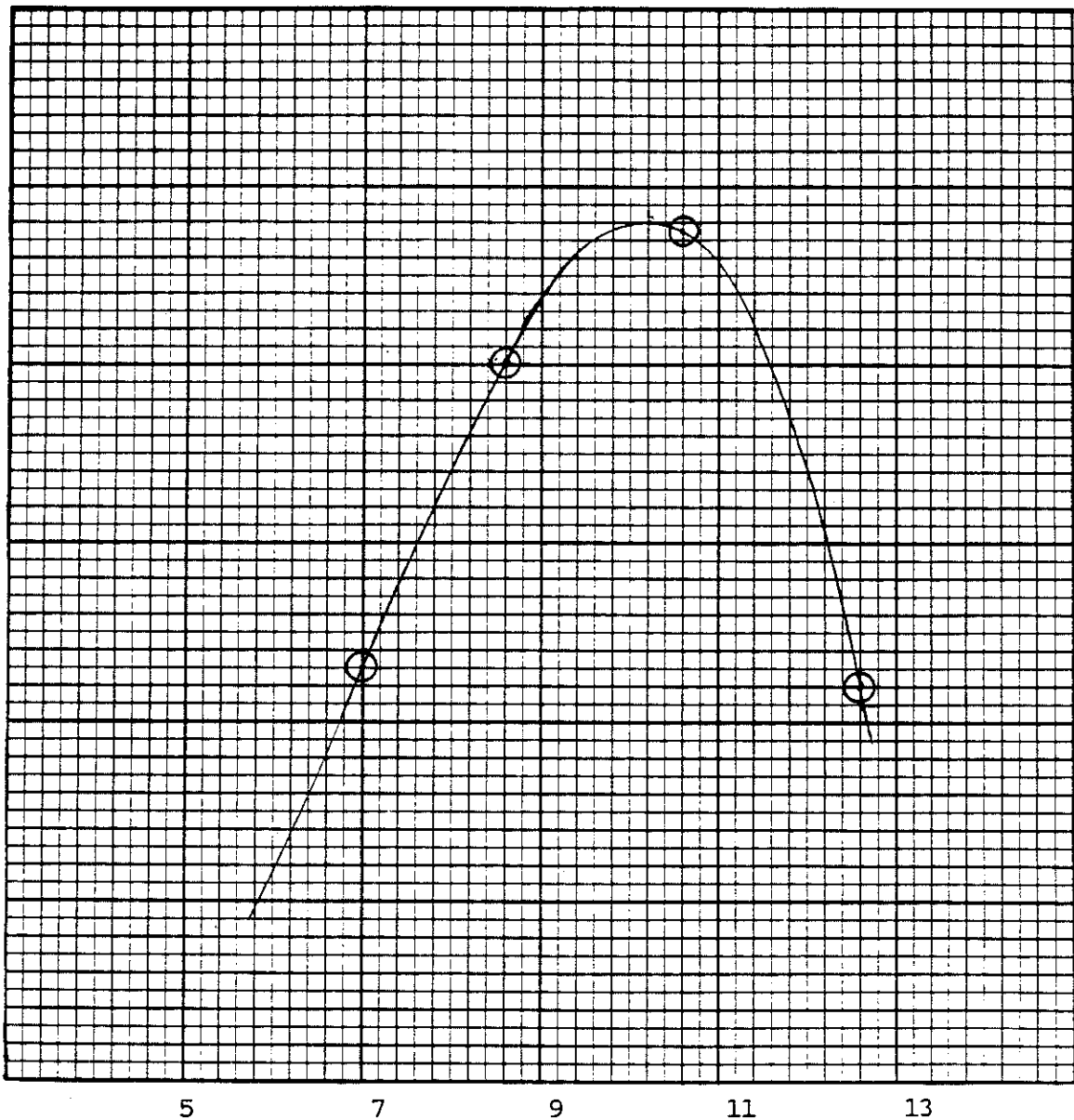
132

130

128

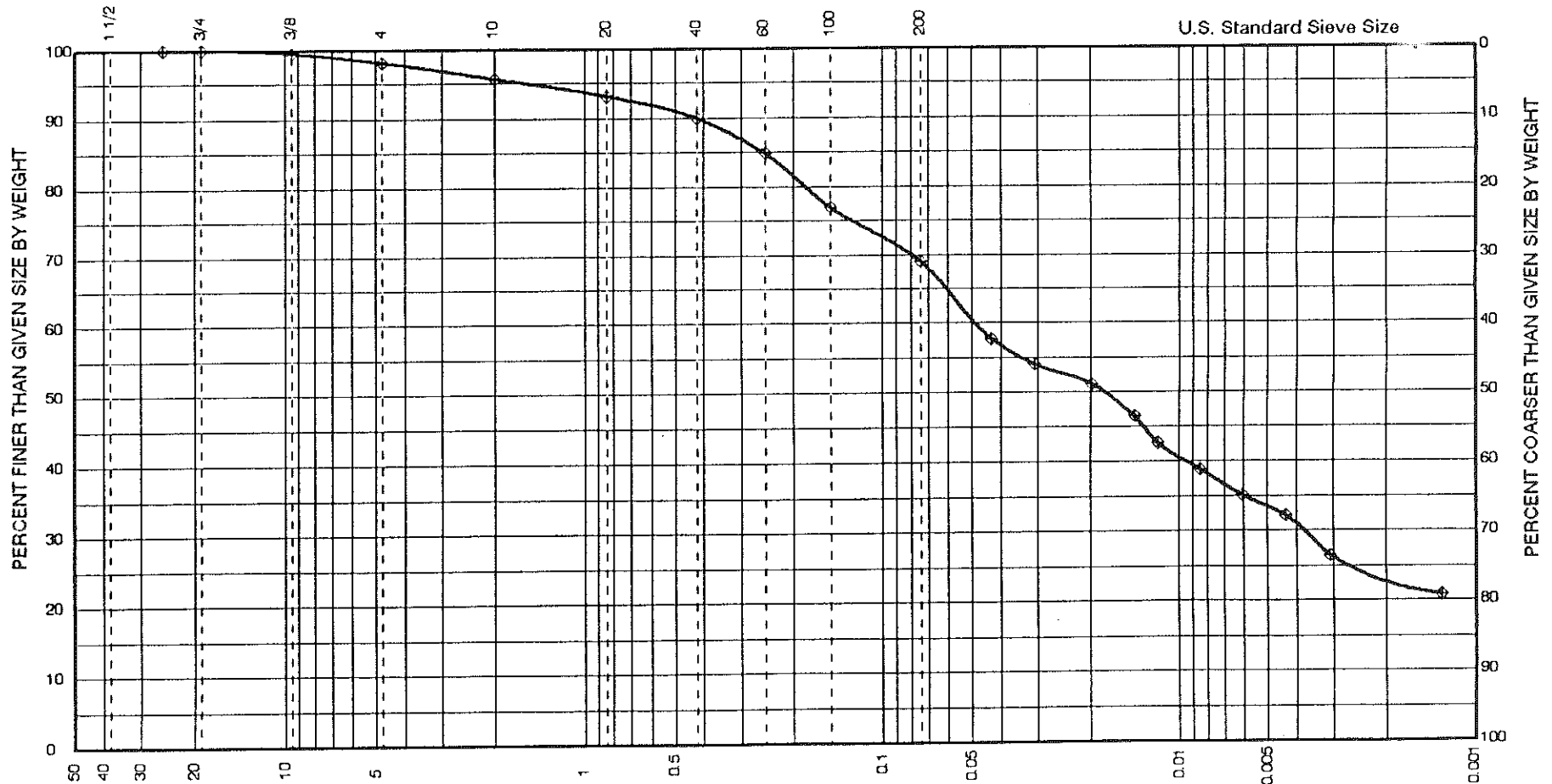
126

124



NTH Consultants, Ltd.
GRAIN SIZE DISTRIBUTION CURVE

Project No. 89365-OW Lab Sample No. 7282 Source I-696 Excavation
 Project Location Dearborn, Michigan For Allen Park Clay Mine - As Built Characteristics
 Boring No. _____ Field Sample No. Block 115 Sample Depth _____ Sample Elev. (Tip) _____
 Sample Description Gray SILTY CLAY with Some Sand and Trace of Gravel
 Sampled By DHH Date 10/24/89 Tested By R.O. Date 10-27-89



Grain Size in MM.

Gravel		Sand			Fines		
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay	Colloids

TABULATION OF LABORATORY TEST DATA

NTH Consultants, Ltd.

ALLEN PARK CLAY MINE
ALLEN PARK, MICHIGAN

Date: 11/18/89

NTH Proj. No.: 89365 OW

Sample Designation: Block 115

Sample Location: Cell II; 3560N 6970E; elevation 579.2

Lab Sample No.: 7282

Date Sampled: 10/24/89

Soil Properties and Description

GRAIN SIZE DISTRIBUTION:

Gravel:	1.9	%
Coarse Sand:	2.4	%
Medium Sand:	5.8	%
Fine Sand:	20.9	%
Silt:	35.7	%
Clay:	33.3	%

ATTERBERG LIMITS

Liquid Limit: 26
Plasticity Index: 12

UNIFIED SOIL CLASSIFICATION: CL

SAMPLE DESCRIPTION:

Gray SILTY CLAY with Some Sand and Trace of Gravel

Modified Proctor Test Result

(Per ASTM D 1557-78)

Maximum Dry Density: 133.6 pcf
Optimum Moisture Content: 10.2 %

Moisture/Density and Permeability Relationship

Moisture	Percent of	Coefficient of
Content:	Maximum Dry Density	Permeability (1)
11.9 %	94.1 %	K = 4.7E - 9 cm/sec

REMARKS:

- 1.
- 2.

Checked By: _____



NTH CONSULTANTS, LTD.

CURVE 2

MOISTURE - DENSITY RELATIONS

PROJECT: Allen Park Clay Mine - Cell II

PROJECT NO.: 89365 OW

LOCATION: Allen Park, Michigan

DATE: 09/04/89

SUPPLIER/SOURCE: I-696 Excavation

TESTED BY: GM

SAMPLE LOCATION: I-696 Stockpile

CHECKED BY: SG

METHOD OF COMPACTION: ASTM D-1557 Method A

LAB SAMPLE NO.: 7013

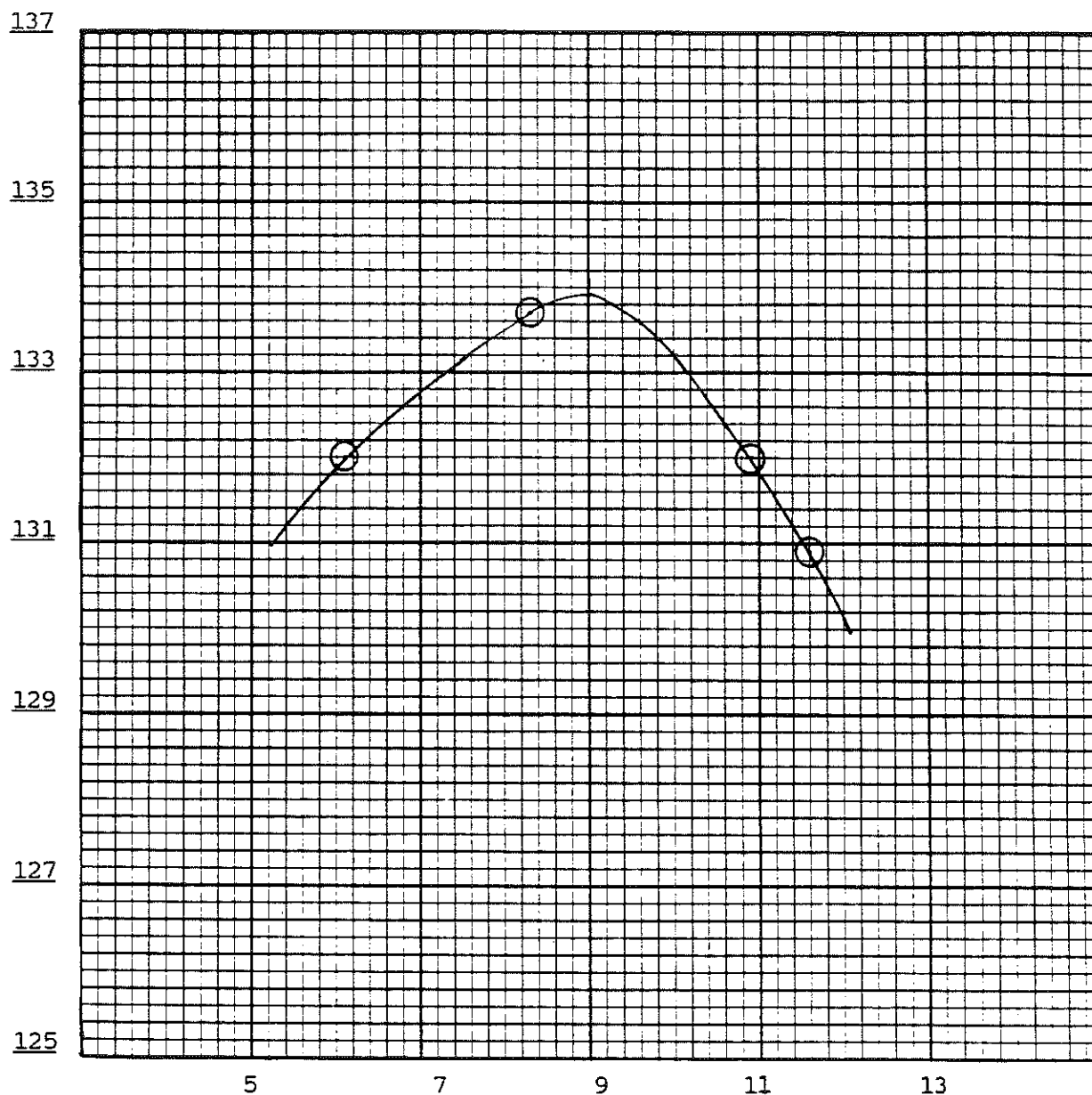
MOLD NO.: B VOLUME: 0.0330 CUBIC FEET

MATERIAL DESIGNATION NO.: Bag 110

SAMPLE DESCRIPTION: Gray **SILTY CLAY** with Some Sand and Trace of Gravel

MAXIMUM DRY DENSITY: 133.9 PCF

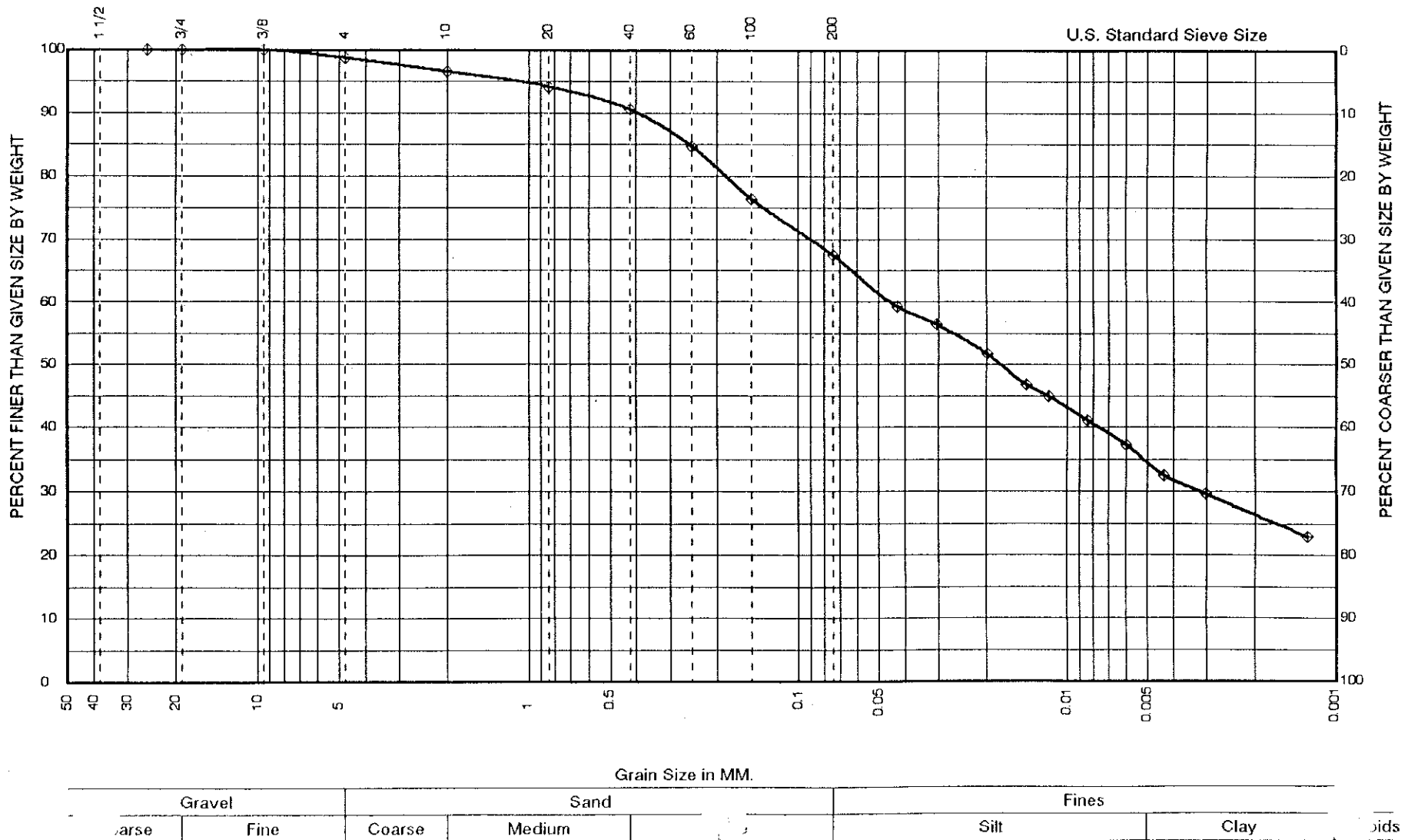
OPTIMUM MOISTURE CONTENT: 9.0 %



NTH Consultants, Ltd.

GRAIN SIZE DISTRIBUTION CURVE

Project No. 89365-OW Lab Sample No. 7013 Source I-696 Excavation
 Project Location Allen Park, Michigan For Allen Park Clay Mine - Material Characteristics
 Boring No. _____ Field Sample No. Bag 110 Sample Depth _____ Sample Elev. (Tip) _____
 Sample Description Gray SILTY CLAY with Some Sand and Trace of Gravel
 Sampled By MJ Date 9/4/89 Tested By E.W. Date 9-8-89



TABULATION OF LABORATORY TEST DATA

NTH Consultants, Ltd.

ALLEN PARK CLAY MINE
ALLEN PARK, MICHIGAN

Date: 10/24/89

NTH Proj. No.: 89365 OW

Sample Designation: Bag 110

Sample Location: I-696 Stockpile

Lab Sample No.: 7013

Date Sampled: 09/04/89

Soil Properties and Description

GRAIN SIZE DISTRIBUTION:

Gravel:	1.0	%
Coarse Sand:	2.0	%
Medium Sand:	6.0	%
Fine Sand:	23.0	%
Silt:	34.0	%
Clay:	34.0	%

ATTERBERG LIMITS

Liquid Limit: 26
Plasticity Index: 12

UNIFIED SOIL CLASSIFICATION: CL

SAMPLE DESCRIPTION:

Gray SILTY CLAY with Some Sand and Trace of Gravel

Modified Proctor Test Result

(Per ASTM D 1557-78)

Maximum Dry Density:	133.9	pcf
Optimum Moisture Content:	9.0	%

REMARKS:

1.

2.

Checked By: _____

CURVE 3

Sample Number

(6) I-696

Description

Dune 421101518 Spun (10 VZ 72) CLAYEY SILT

Method

ASTA D1557-8

Some
C-4.5
-6)W_{max}

9.1

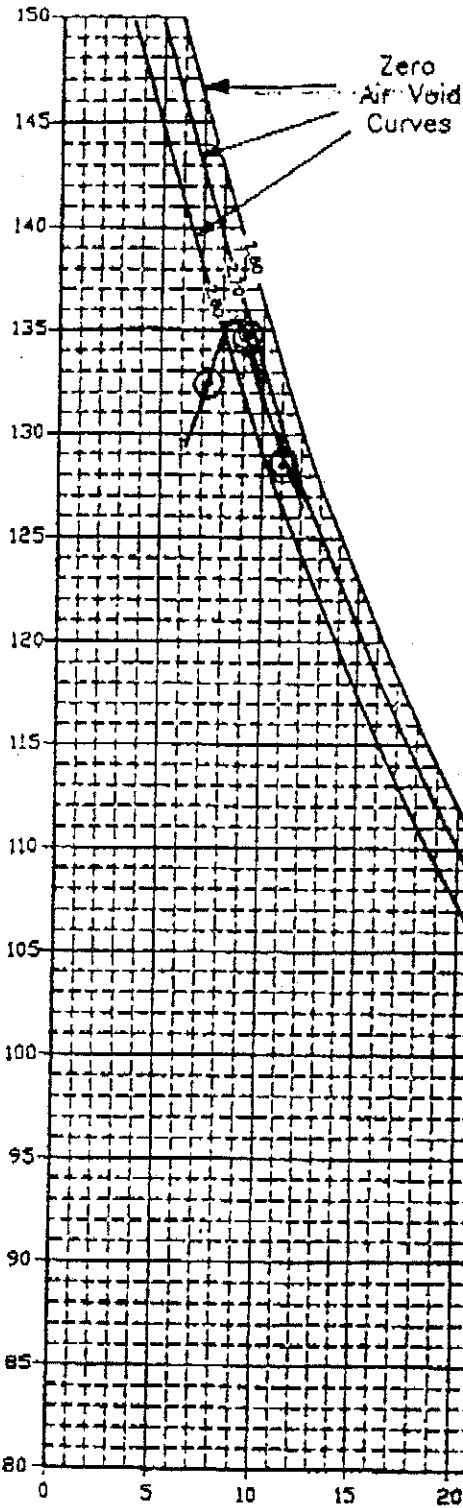
X

MOLD volume

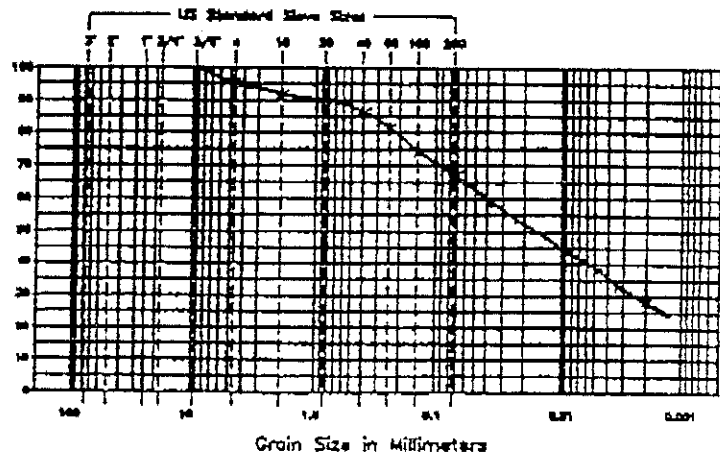
0.075

d

Trial no.	1	2	3			
Moist no.	62184	62194	62184			
Wt. moist soil & mold	106.70	104.95	105.23			
Tare wt. mold	58.66	58.66	58.66			
Wt. moist soil	50.04	49.29	46.57			
Wt. dry soil	44.1	41.9	42.8			
Moisture con. no.	2.7	3.9	2.3			
Wt. moist sample & can	242.25	242.85	242.18			
Wt. dry sample & can	223.27	223.61	221.60			
Can tare wt.	24.52	24.49	23.00			
Wt. water (W _w)	59.01	24.24	34.58			
Wt. dry sample (W _d)	46.45	34.62	31.46			
Water content (%)	9.1	7.2	11.0			
Wt. dry soil						
Dry density - pcf	134.5	132.4	129.0			

Dry Weight
(lbs./ft.³)Moisture
(% of dry wt.)

Percent Finer by Weight



D ₁₀	NA
D ₃₀	NA
D ₅₀	NA
C _u	NA
C _z	NA

SUMMARY

Maximum Density (pcf)	135.5
Optimum Moisture (%)	9.5

Figure

MOISTURE-DENSITY RELATIONSHIP OF SOIL

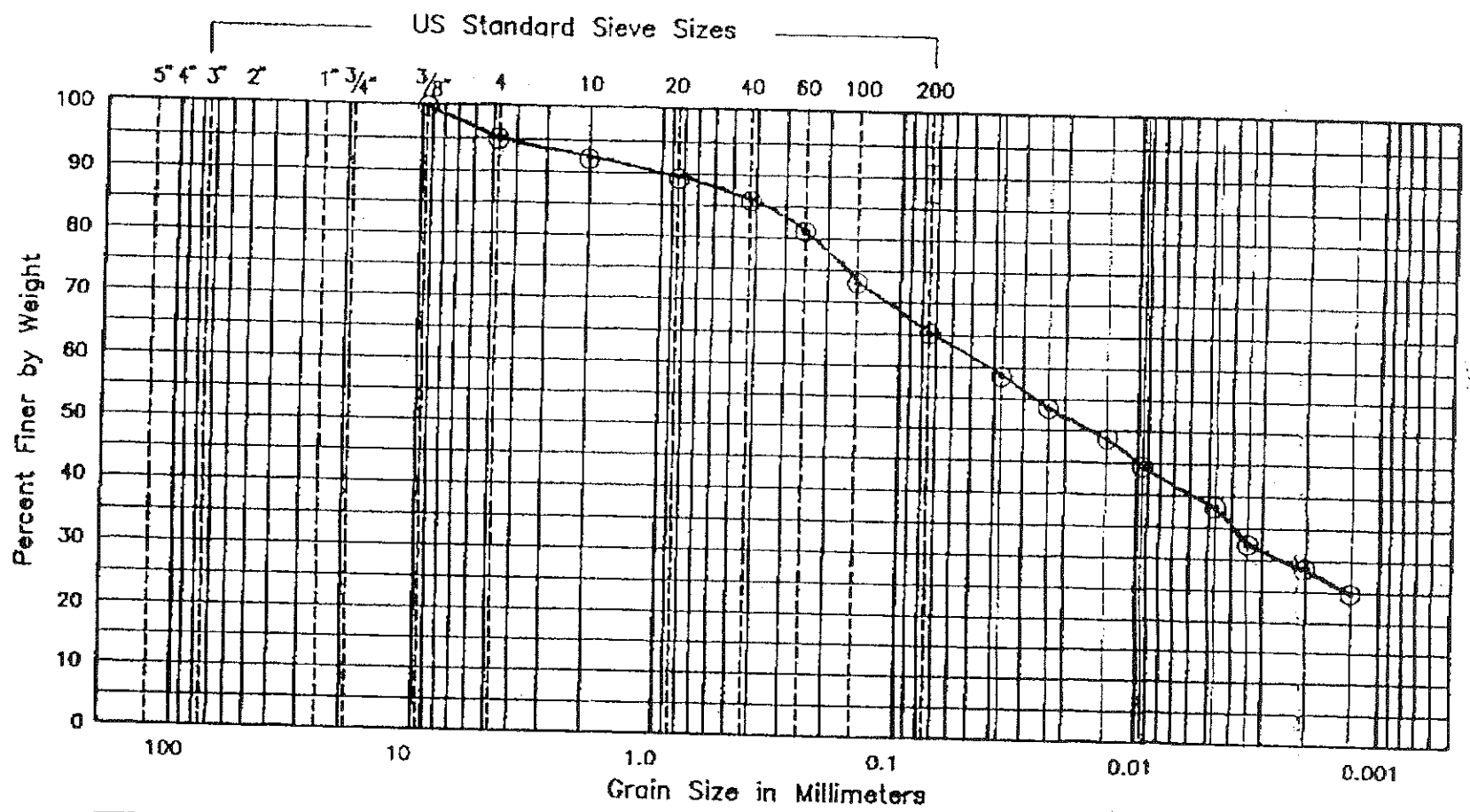
Project EC51 Ford Motor Co. / M.T.

Project No. 907-3078

Date 7-12-90 Tested By JECM

Approved By JDPD

Golder Associates



Cobbles	Gravel		Sand			Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay

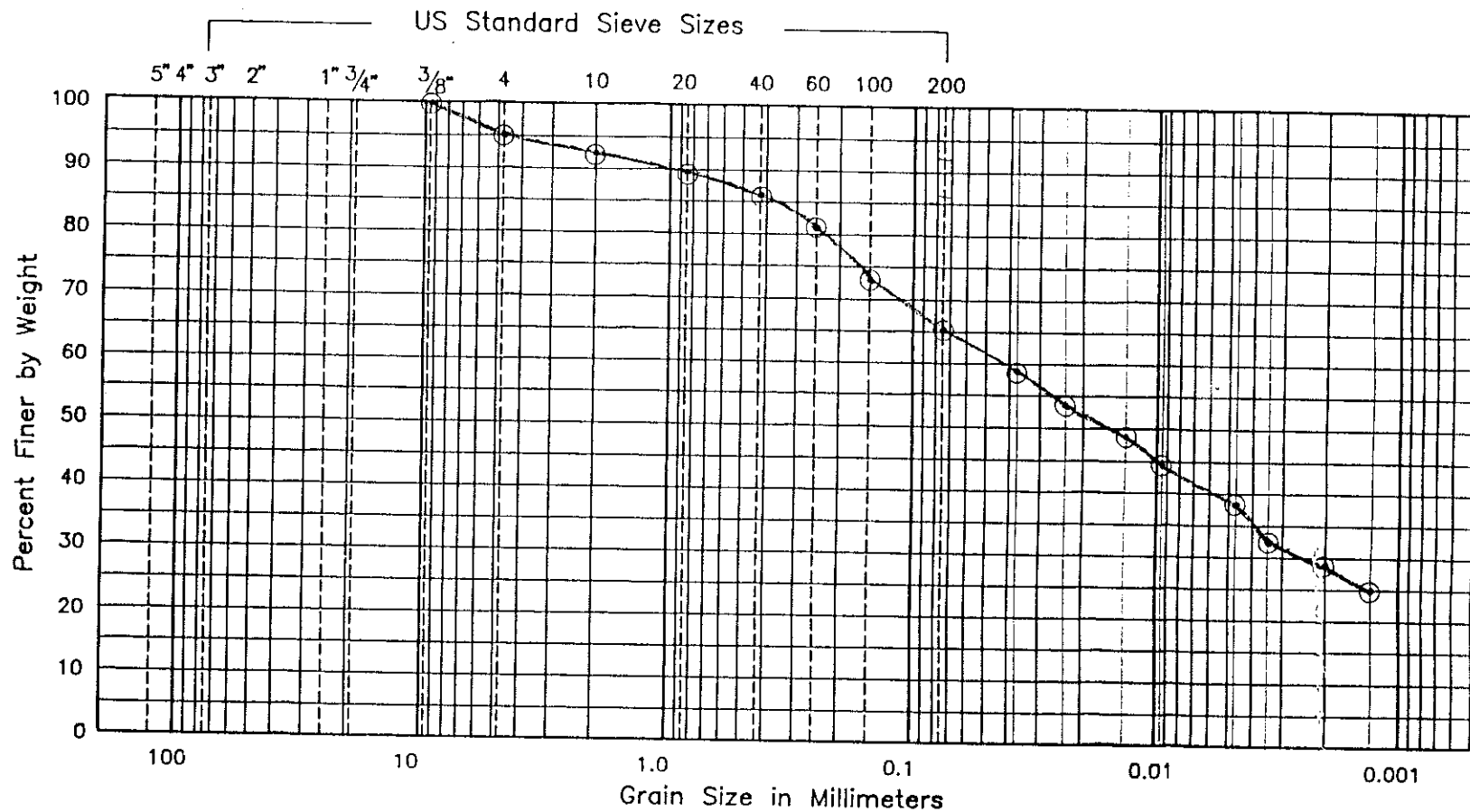
Boring No.	Elev. or Depth	W _n	W _L	W _p	I _p	Description
E-646 (6)		9.1	25	11	14	Dark yellowish brown (10 YR 4/2). CLAYEY SILT, some c-f SAND, tr f gravel, (CL).

GRAIN SIZE DISTRIBUTION

Project: EGS / Ford Active Co. / AT
 Project No. 103-3073
 Date: 2-12-2010
 Tested by: BIC
 Approved by: BIC
 Golder Associates

GRAIN SIZE DISTRIBUTION

Project: CS 1 Road Master Co. 1 A I
 Project No. 103-3078 Date 3-7-90 Tested By TRCA Approved By TRC
 Golder Associates

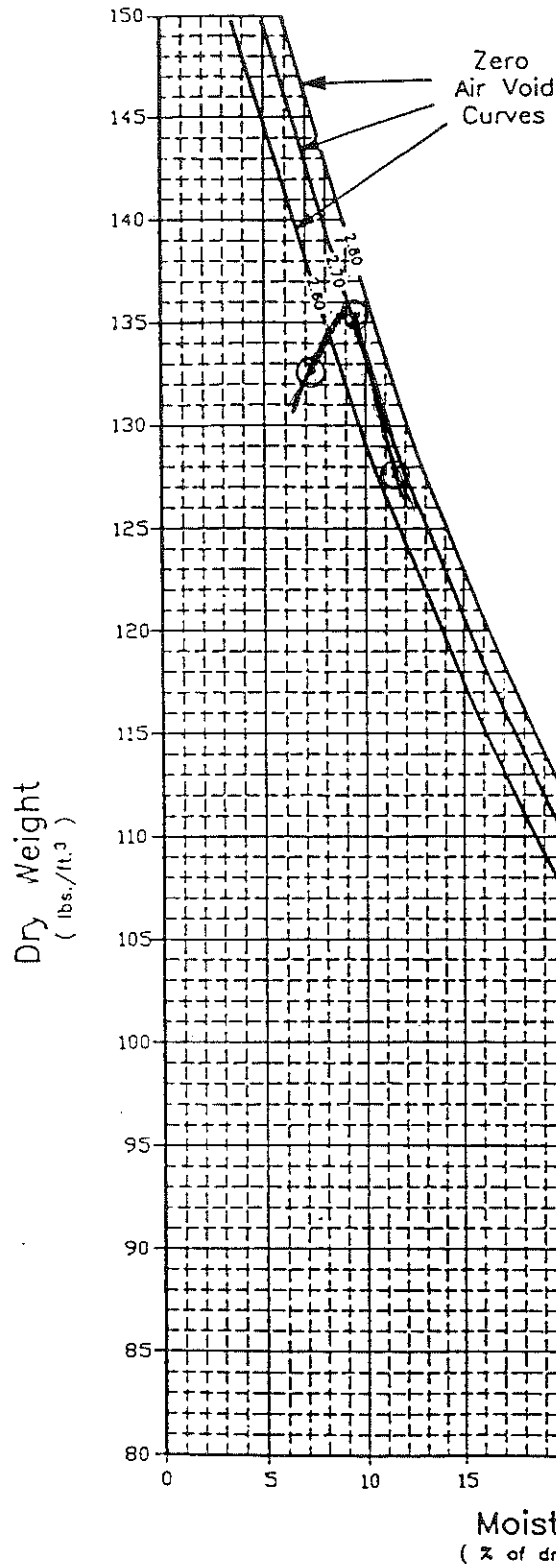


Cobbles	Gravel		Sand			Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt or Clay

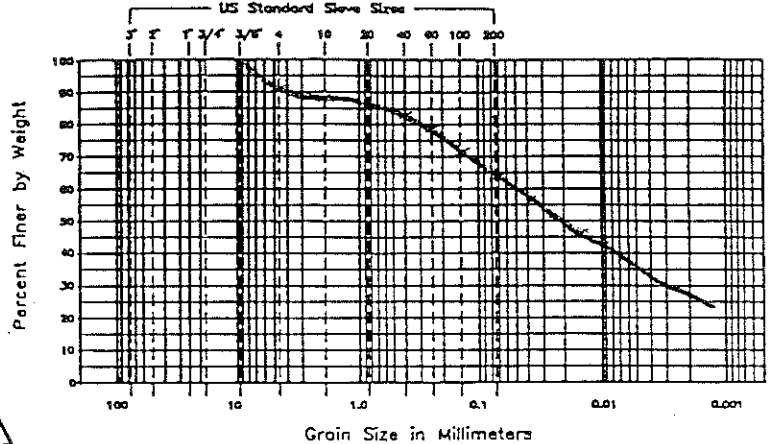
Boring No.	Elev. or Depth	W _n	W _L	W _p	I _p	Description
I-696 (6)		9.1	25	11	14	Dark yellowish brown (10 YR 7/2), CLAYEY SILT, some c-f SAND, tr f gravel, (CL).

CURVE 3A

Sample Number: 7 I-696
 Description: Gravelly L.M.W. (S.Y.R. 3/2) CLAYEY SILT, some c-f
 Method: ASTM D1557-C
 W_{opt} 9.3 % MOLD volume 0.075 cf 11.2 gravel (L)



Trial no.	1	2	3
Mold no.	40184	40184	40184
Wt. moist soil & mold	10303.5	10514	10517.5
Tare wt. mold	5666	5666	5666
Wt. moist soil	5637.5	4848	4851.5
Wet density - pcf	140.1	142.5	142.4
Moisture can no.	0	21	20
Wt. moist sample & can	630.61	565.44	465.39
Wt. dry sample & can	583.29	533.67	429.14
Can tare wt.	26.00	45.18	44.98
Wt. water (W _w)	44.32	37.07	38.25
Wt. dry sample (W _s)	509.29	488.49	382.16
Water content (w)	9.3	7.3	11.5
Wt. dry soil			
Dry density - pcf	135.5	132.8	127.7



D ₁₀	NA
D ₃₀	NA
D ₆₀	NA
C _u	NA
C _z	NA

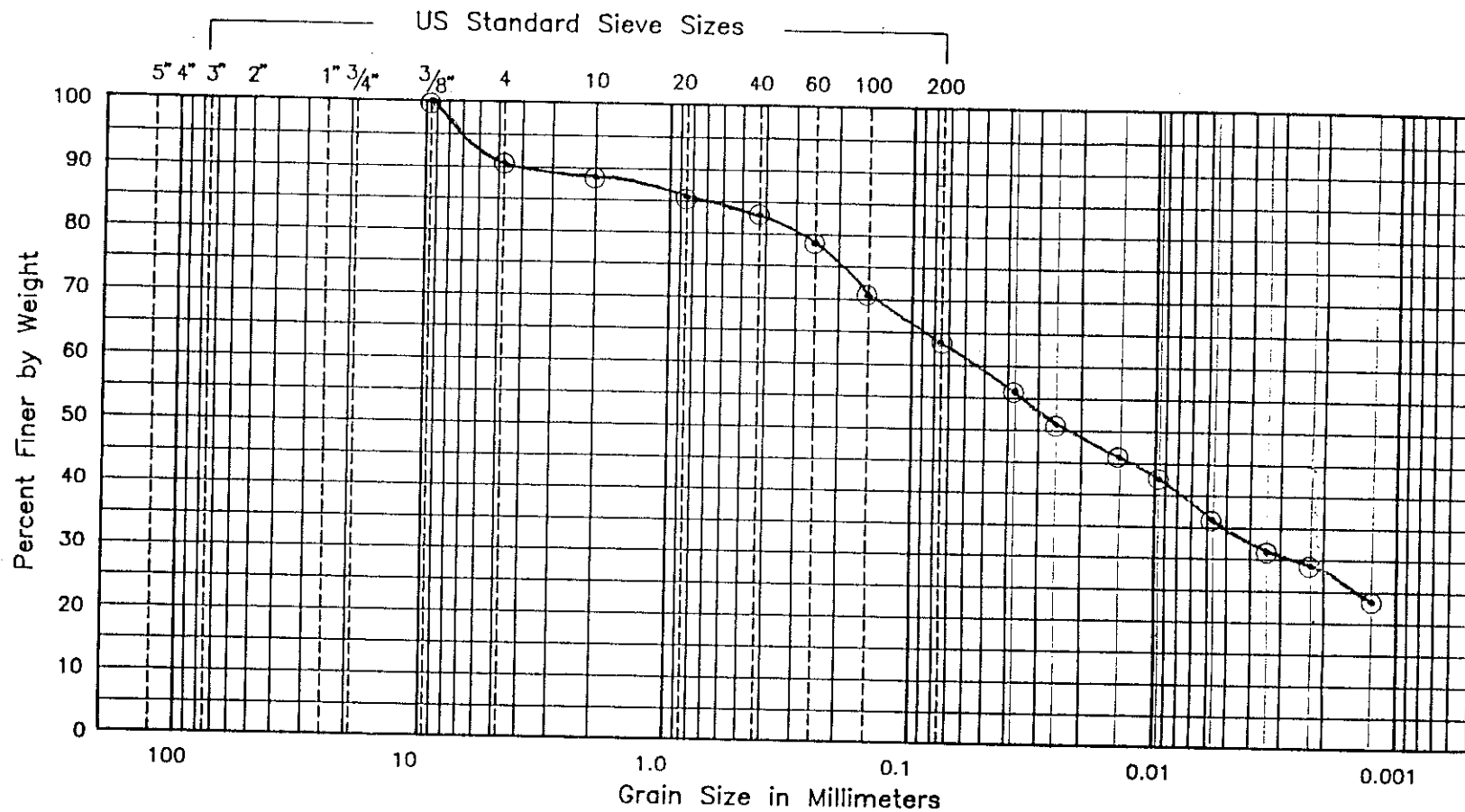
SUMMARY	
Maximum Density (pcf)	135.5
Optimum Moisture (%)	9.0

Figure
 MOISTURE-DENSITY RELATIONSHIP OF SOIL

Project ECS / Ford Motor Co. / MI
 Project No. 903-3078 Date 7-12-90 Tested By ICM Approved By JD Golder Associates

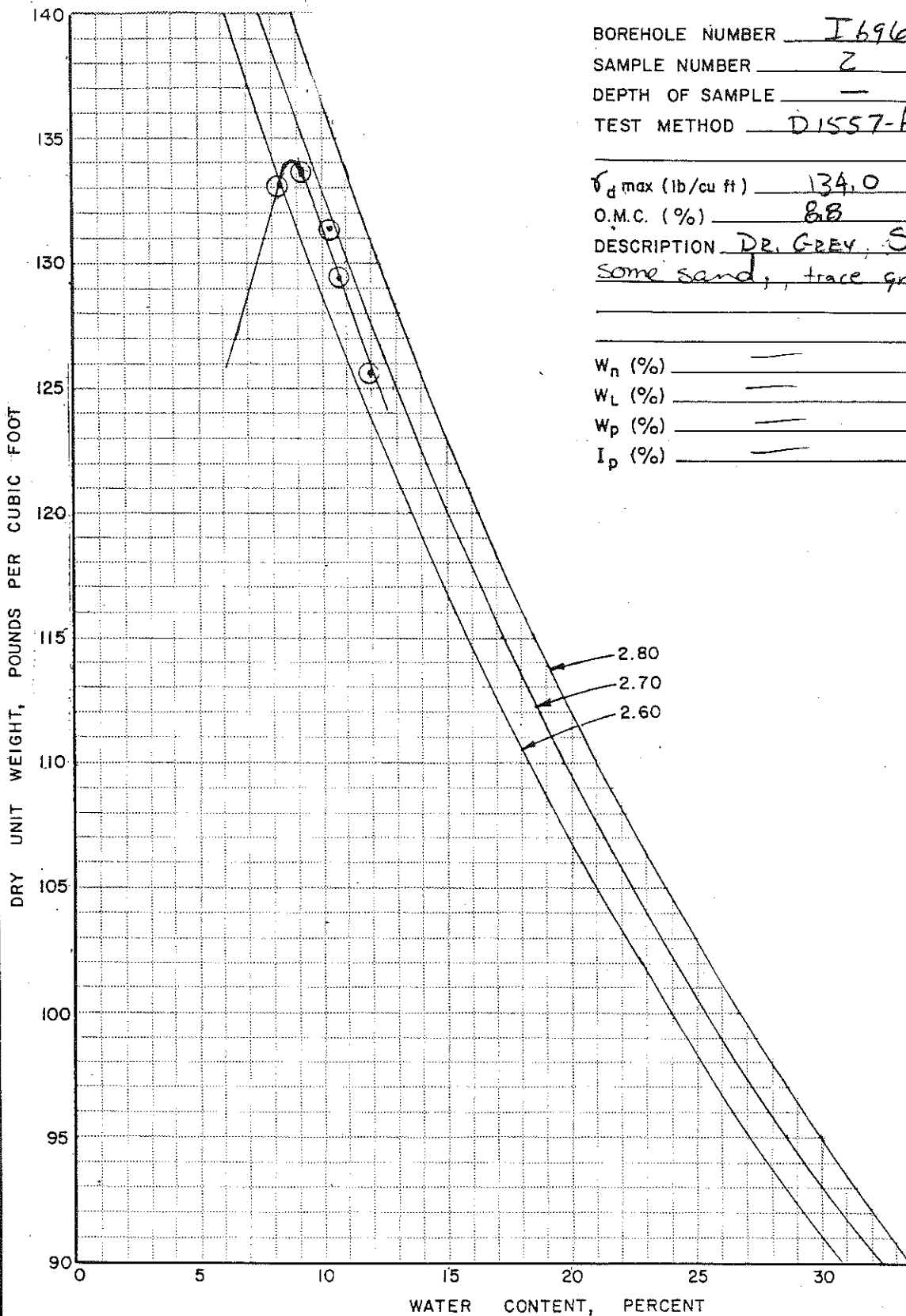
GRAIN SIZE DISTRIBUTION

Project ECS / 1st & 2nd Ave. Col. MT
 Project No. 903-3019 Date 7-12-90 Tested By TR/A Approved By DPV
 Golder Associates



COMPACTION TEST RESULTS

CURVE 4



BOREHOLE NUMBER I 696
 SAMPLE NUMBER 2
 DEPTH OF SAMPLE —
 TEST METHOD DIS57-A

γ_d max (lb/cu ft) 134.0
 O.M.C. (%) 8.8
 DESCRIPTION DR. GREY, SILTY CLAY,
some sand, trace gravel

w_n (%) —
 w_L (%) —
 w_p (%) —
 I_p (%) —

Date 6/4/90
 Job No. 903-3078

Golder Associates

Drawn WMS
 Checked RAW
 Approved BSP



NTH CONSULTANTS, LTD.

CURVE 5

MOISTURE - DENSITY RELATIONS

PROJECT: Allen Park Clay Mine - Cell II

PROJECT NO.: 89365 OW

LOCATION: Allen Park, Michigan

DATE: 8/18/89

SUPPLIER/SOURCE: Cell II Native Soil

TESTED BY: DM

SAMPLE LOCATION: 3650N, 7300E

CHECKED BY: SG

METHOD OF COMPACTION: ASTM D-1557 Method A

LAB SAMPLE NO.: 6480

MOLD NO.: B VOLUME: 0.0332 CUBIC FEET

MATERIAL DESIGNATION NO.: Block 104

SAMPLE DESCRIPTION: Gray SILTY CLAY with Little Sand and Gravel

MAXIMUM DRY DENSITY: 132.4 PCF

OPTIMUM MOISTURE CONTENT: 9.4 %

134

132

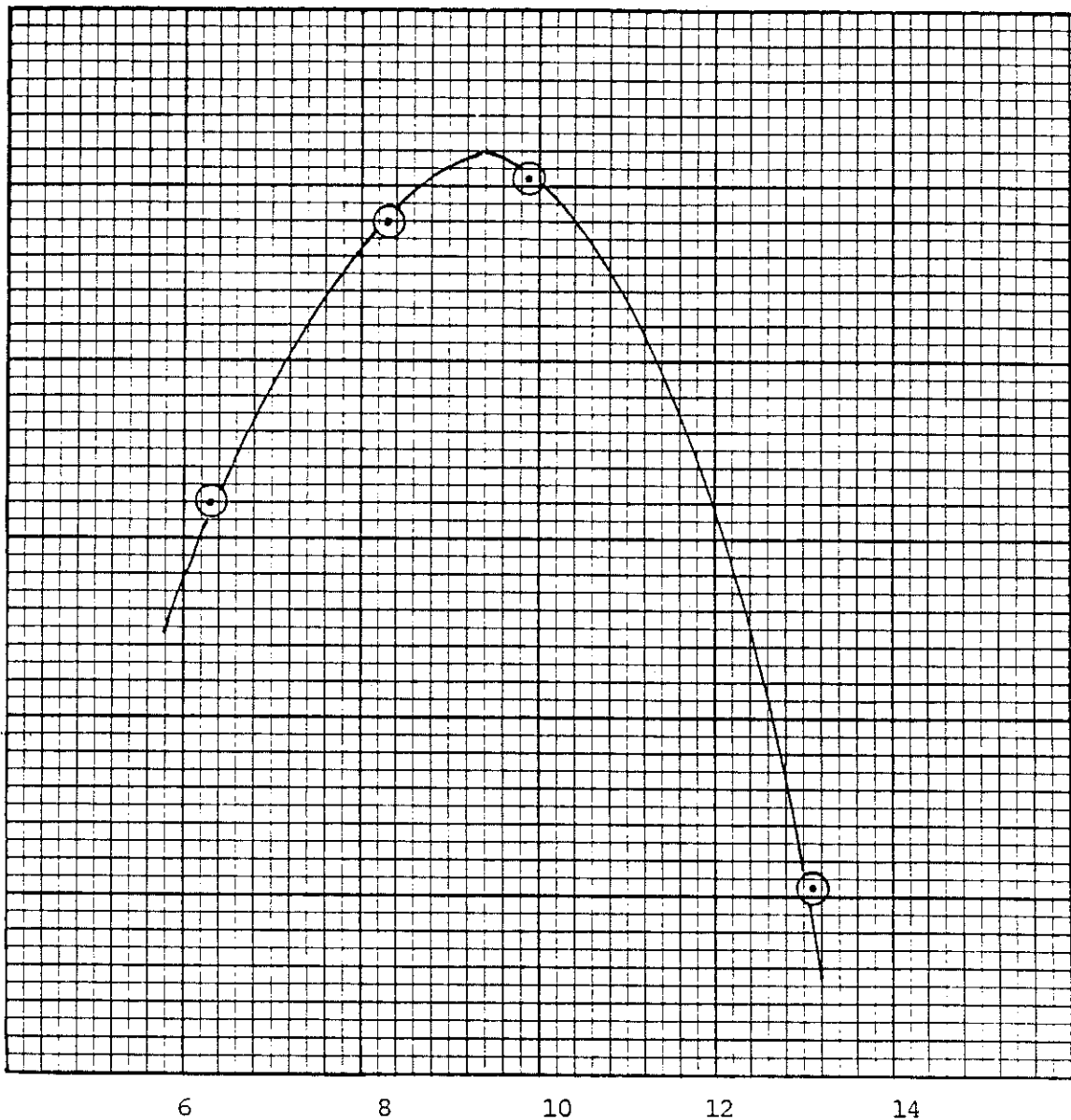
130

128

126

124

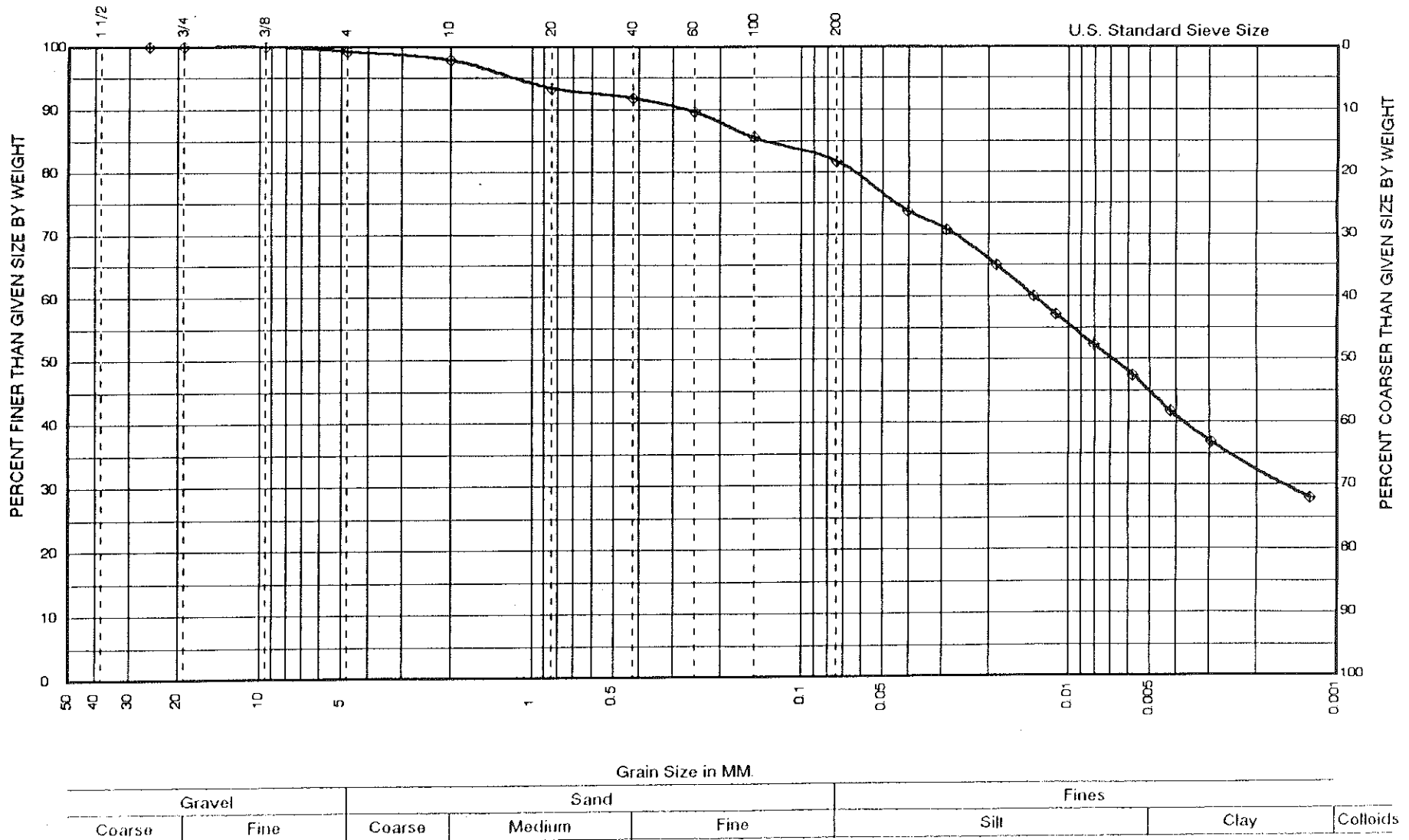
122



NTH Consultants, Ltd.

GRAIN SIZE DISTRIBUTION CURVE

Project No. 89365 OW Lab Sample No. 6480 Source Cell II Native Soil
 Project Location Allen Park, Michigan For Allen Park Clay Mine - Material Characteristics
 Boring No. _____ Field Sample No. Block 104 Sample Depth _____ Sample Elev. (Tip) _____
 Sample Description Gray SILTY CLAY with Little Sand and Trace of Gravel
 Sampled By MJ Date 8/10/89 Tested By MS Date 8/17/89



TABULATION OF LABORATORY TEST DATA

NTH Consultants, Ltd.

ALLEN PARK CLAY MINE
ALLEN PARK, MICHIGAN

Date: 08/29/89

NTH Proj. No.: 89365 OW

Sample Designation: Block 104

Sample Location: Cell II South Stabilization Berm, 3650N, 7300E

Lab Sample No.: 6480

Date Sampled: 08/10/89

Soil Properties and Description

GRAIN SIZE DISTRIBUTION:

Gravel:	1.0	%
Coarse Sand:	1.0	%
Medium Sand:	6.0	%
Fine Sand:	10.0	%
Silt:	37.0	%
Clay:	45.0	%

ATTERBERG LIMITS

Liquid Limit: 32
Plasticity Index: 15

UNIFIED SOIL CLASSIFICATION: CL

SAMPLE DESCRIPTION:

Gray SILTY CLAY with Little Sand and Trace of Gravel

Modified Proctor Test Result

(Per ASTM D 1557-78)

Maximum Dry Density: 132.4 pcf
Optimum Moisture Content: 9.4 %

Moisture/Density and Permeability Relationship

Moisture Content:	Percent of Maximum Dry Density	Coefficient of Permeability (1)
12.8 %	91.4 %	$K = 6.9E - 8$ cm/sec

REMARKS:

1.

2.

Checked By: _____



NTH CONSULTANTS, LTD.

CURVE 6

MOISTURE - DENSITY RELATIONS

PROJECT: Allen Park Clay Mine - Cell II

PROJECT NO.: 89365 OW

LOCATION: Allen Park, Michigan

DATE: 11/18/89

SUPPLIER/SOURCE: I-696 Excavation

TESTED BY: JN

SAMPLE LOCATION: Cell II South Slope

CHECKED BY: SG

METHOD OF COMPACTION: ASTM D-1557 Method A

LAB SAMPLE NO.: 7263

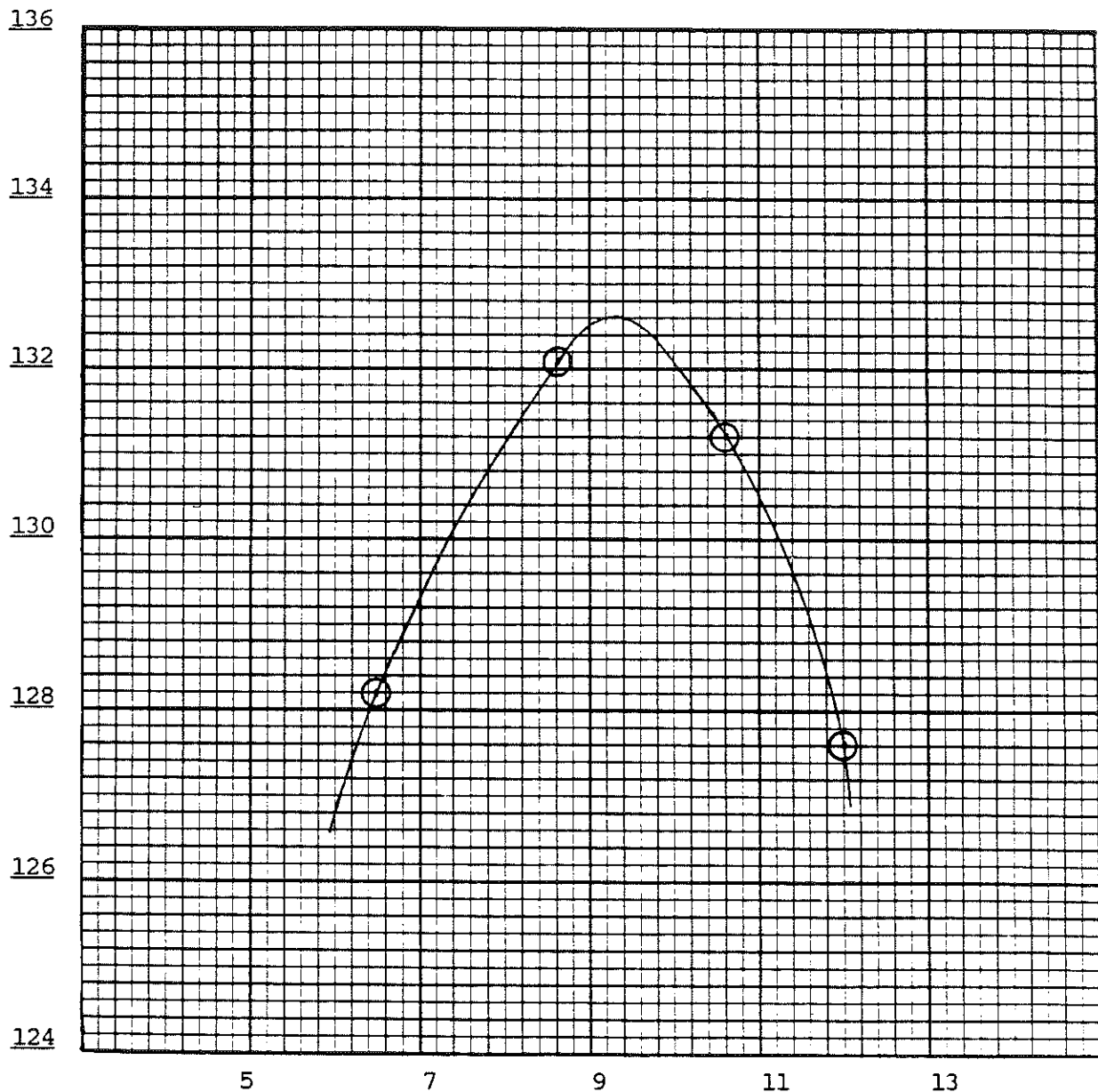
MOLD NO.: A VOLUME: 0.0330 CUBIC FEET

MATERIAL DESIGNATION NO.: Bag 113

SAMPLE DESCRIPTION: Gray **SILTY CLAY** with Some Sand and Trace of Gravel

MAXIMUM DRY DENSITY: 132.6 PCF

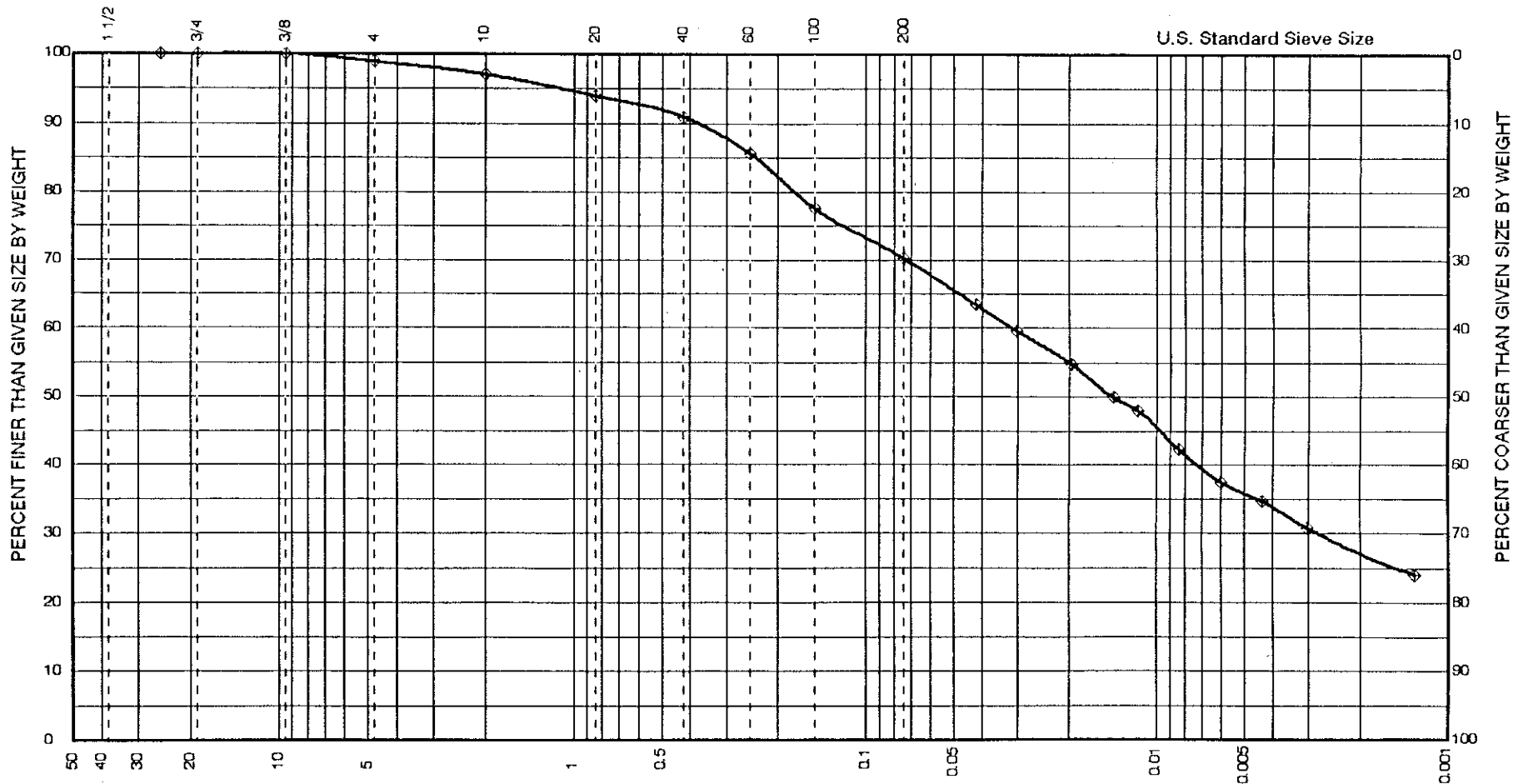
OPTIMUM MOISTURE CONTENT: 9.3 %



NTH Consultants, Ltd.

GRAIN SIZE DISTRIBUTION CURVE

Project No. 89365-OW Lab Sample No. 7263 Source I-696 Excavation
 Project Location Dearborn, Michigan For Allen Park Clay Mine - Material Characteristics
 Boring No. _____ Field Sample No. Bag 113 Sample Depth _____ Sample Elev. (Tip) _____
 Sample Description Gray SILTY CLAY with Some Sand and Trace of Gravel
 Sampled By DHH Date 10/18/89 Tested By R.O. Date 10-23-89



Grain Size in MM.

Gravel		Sand			Fines	
Coarse	Fine	Coarse	Medium		Silt	Clay

TABULATION OF LABORATORY TEST DATA

NTH Consultants, Ltd.

ALLEN PARK CLAY MINE
ALLEN PARK, MICHIGAN

Date: 11/18/89

NTH Proj. No.: 89365 OW

Sample Designation: Bag 113

Sample Location: Cell II South Slope

Lab Sample No.: 7263

Date Sampled: 10/18/89

Soil Properties and Description

GRAIN SIZE DISTRIBUTION:

Gravel:	1.2	%
Coarse Sand:	1.8	%
Medium Sand:	6.1	%
Fine Sand:	20.7	%
Silt:	34.4	%
Clay:	35.8	%

ATTERBERG LIMITS

Liquid Limit: 27
Plasticity Index: 13

UNIFIED SOIL CLASSIFICATION: CL

SAMPLE DESCRIPTION:

Gray SILTY CLAY with Some Sand and Trace of GRavel

Modified Proctor Test Result

(Per ASTM D 1557-78)

Maximum Dry Density:	132.6	pcf
Optimum Moisture Content:	9.3	%

REMARKS:

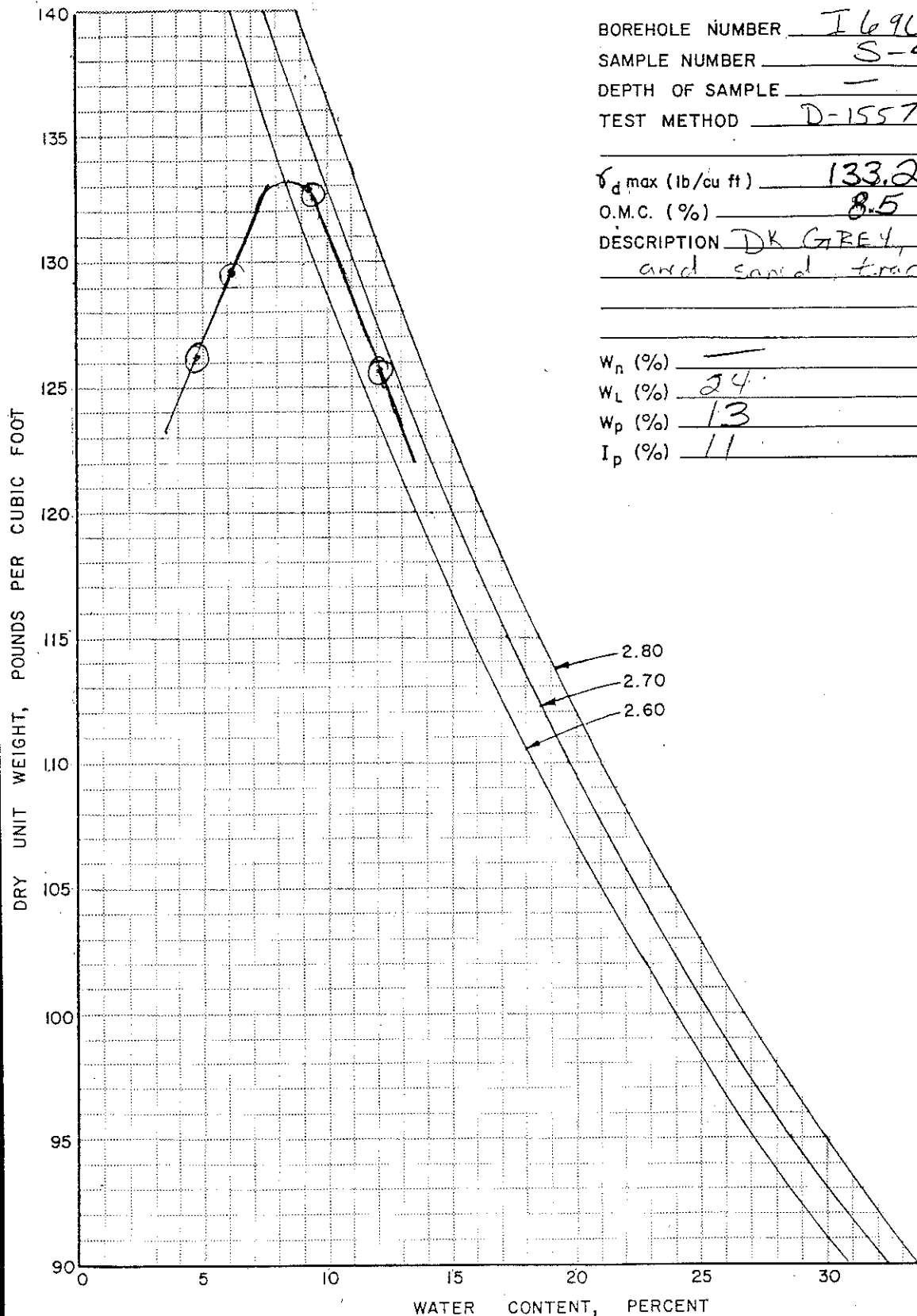
1.

2.

Checked By: _____

COMPACTION TEST RESULTS

CURVE 7



BOREHOLE NUMBER I 696

SAMPLE NUMBER S-4

DEPTH OF SAMPLE -

TEST METHOD D-1557A

γ_d max (lb/cu ft) 133.2

O.M.C. (%) 8.5

DESCRIPTION DK GREY, SILTY CLAY,
and sand trace gravel

W_n (%) -

W_L (%) 24

W_p (%) 13

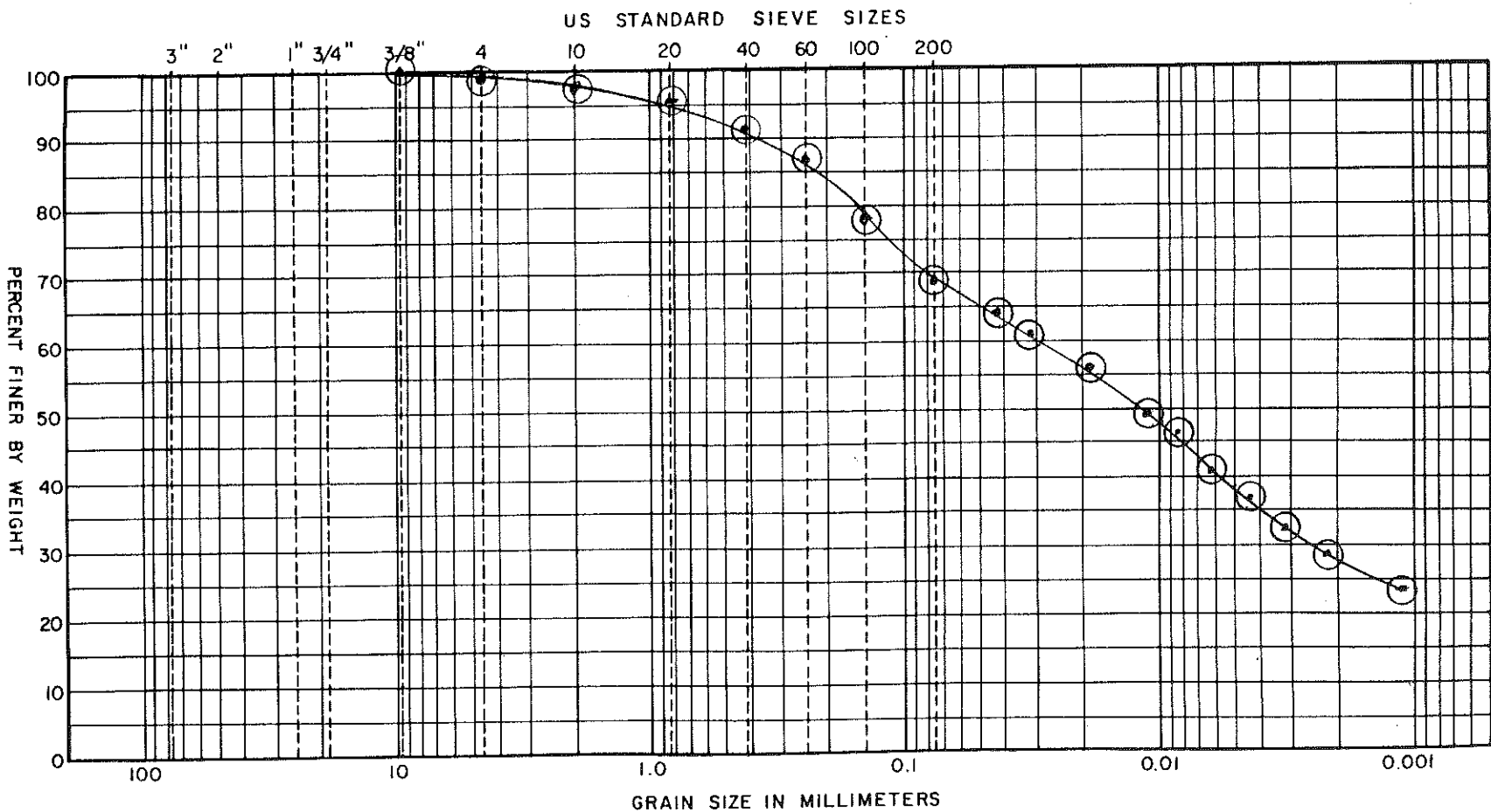
I_p (%) 11

Date 6/14/90
Job No. 003-3078

Golder Associates

Drawn Wms
Checked BCP
Approved -

GRAIN SIZE DISTRIBUTION



COBBLES	GRAVEL		SAND			FINES	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT OR CLAY	

BORING NO.	ELEV. OR DEPTH	W _n	W _L	W _p	I _p	DESCRIPTION OR CLASSIFICATION
I696	—	—	24	13	11	DK. GREY, SILTY CLAY, and sand trace gravel (CL)

FIGURE

Date 6/22/90
Job No. 903-3078

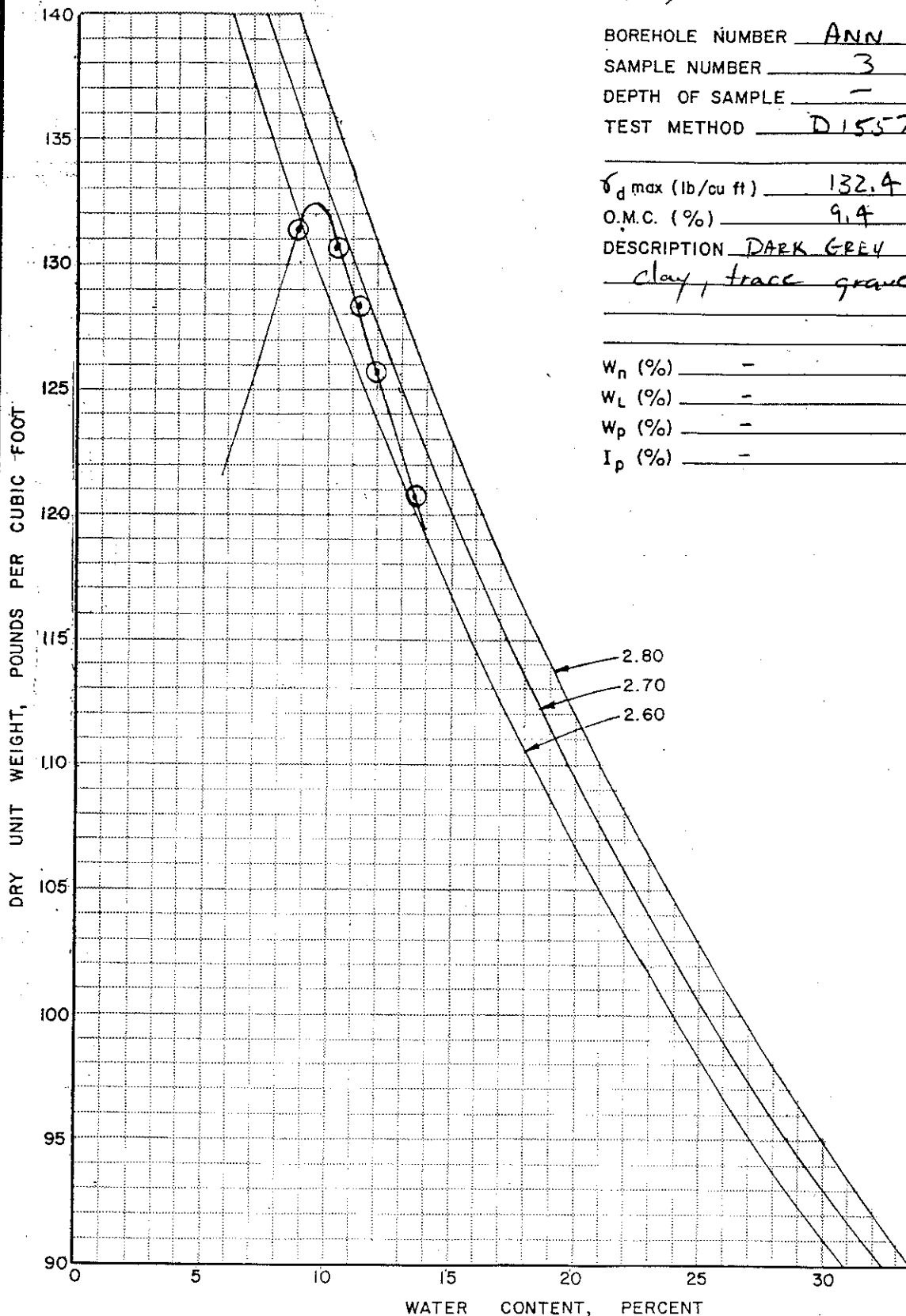
Golder Associates

Drawn WMS
Checked BGP
Reviewed

COMPACTION TEST RESULTS

FIGURE

Sampled 5/31/AJ/29/95



BOREHOLE NUMBER ANN ARBOR

SAMPLE NUMBER 3

DEPTH OF SAMPLE -

TEST METHOD D1557A

σ_d max (lb/cu ft) 132.4

O.M.C. (%) 9.4

DESCRIPTION DARK GREY SAND, and silty clay, trace gravel

W_n (%) -

W_L (%) -

W_p (%) -

I_p (%) -

Date 6/4/90

Job No. 903-3078

Golder Associates

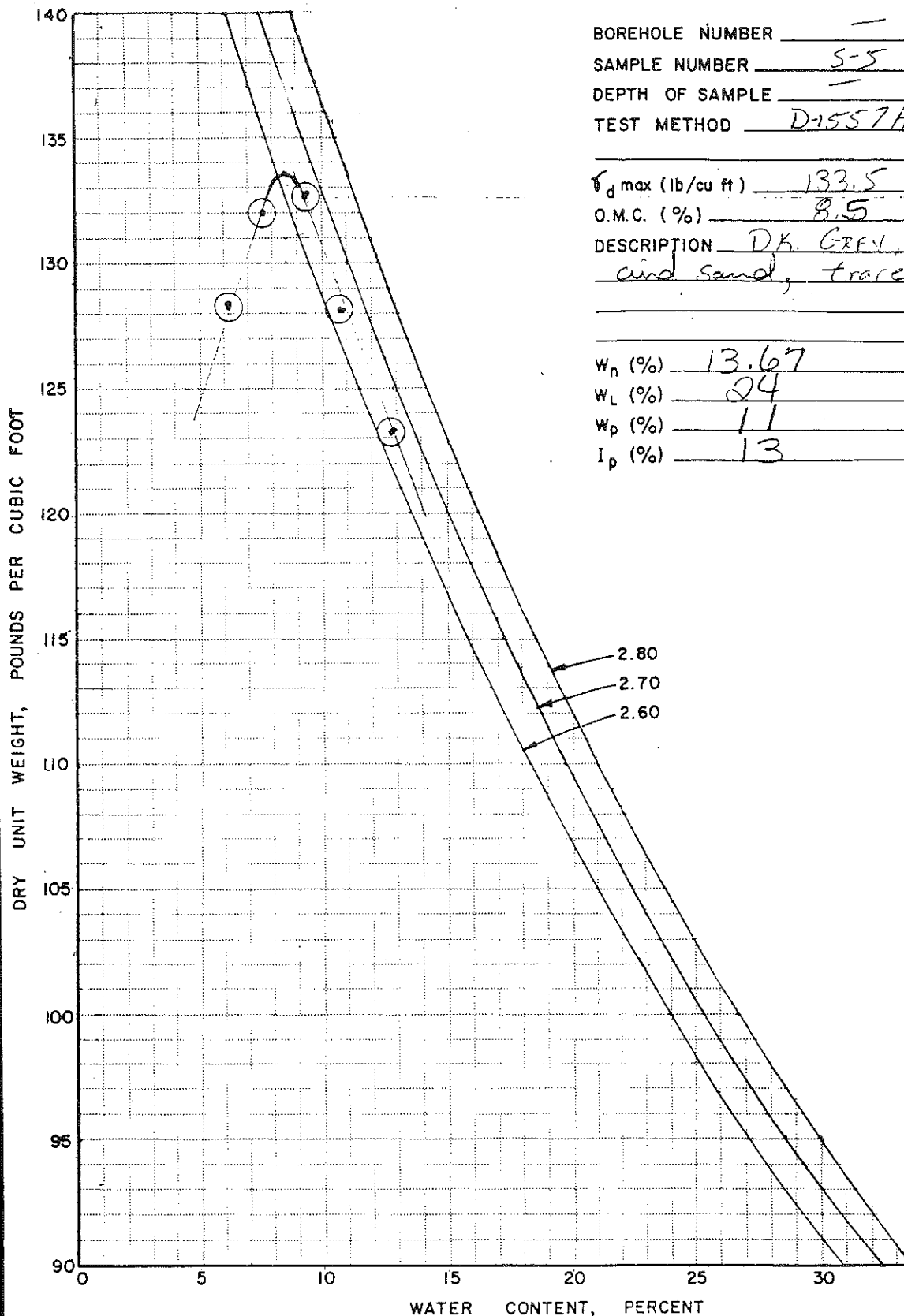
Drawn WMS

Checked WMS

Approved -

COMPACTION TEST RESULTS

FIGURE



BOREHOLE NUMBER _____

SAMPLE NUMBER S-5

DEPTH OF SAMPLE _____

TEST METHOD D-1557A

γ_d max (lb/cu ft) 133.5

O.M.C. (%) 8.5

DESCRIPTION DK. GRAY, SILTY CLAY
and sand, trace gravel (CL)

w_n (%) 13.67

w_L (%) 24

w_p (%) 11

I_p (%) 13

Date 6/20/90
Job No. 903-2278

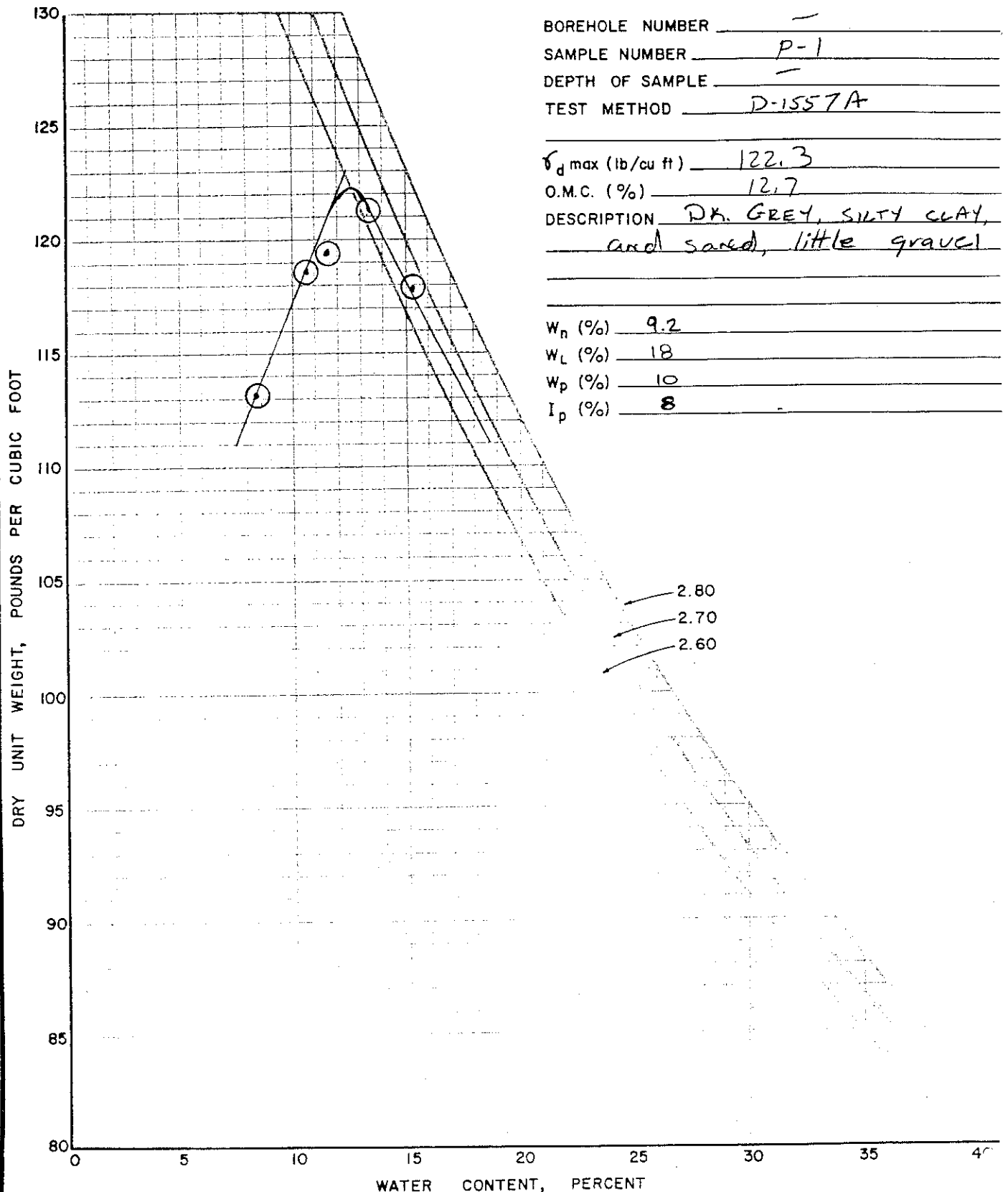
Golder Associates

Drawn Wm
Checked BGP
Approved _____

CURVE 10

COMPACTION TEST RESULTS

FIGURE



Date 6/25/80

Job No. 903-3078
907-1045

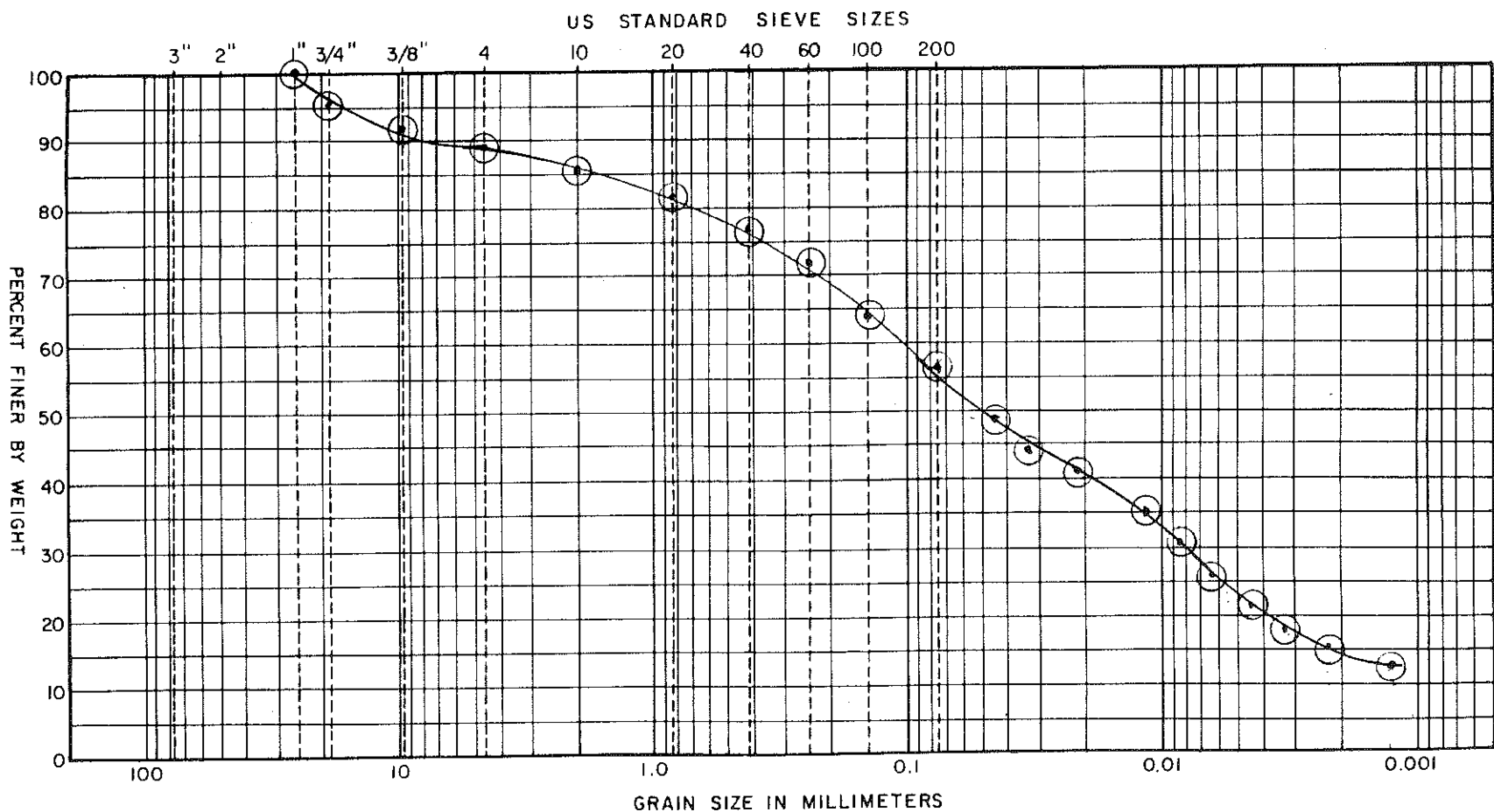
Golder Associates

Drawn WMS

Checked MA

Approved _____

GRAIN SIZE DISTRIBUTION



COBBLES	GRAVEL		SAND			FINES
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT OR CLAY

BORING NO.	ELEV. OR DEPTH	w_n	w_L	w_p	I_p	DESCRIPTION OR CLASSIFICATION
P-1	—	9.19	18	10	8	DK. GREY, SILTY CLAY, and sand little gravel. (CL)

FIGURE

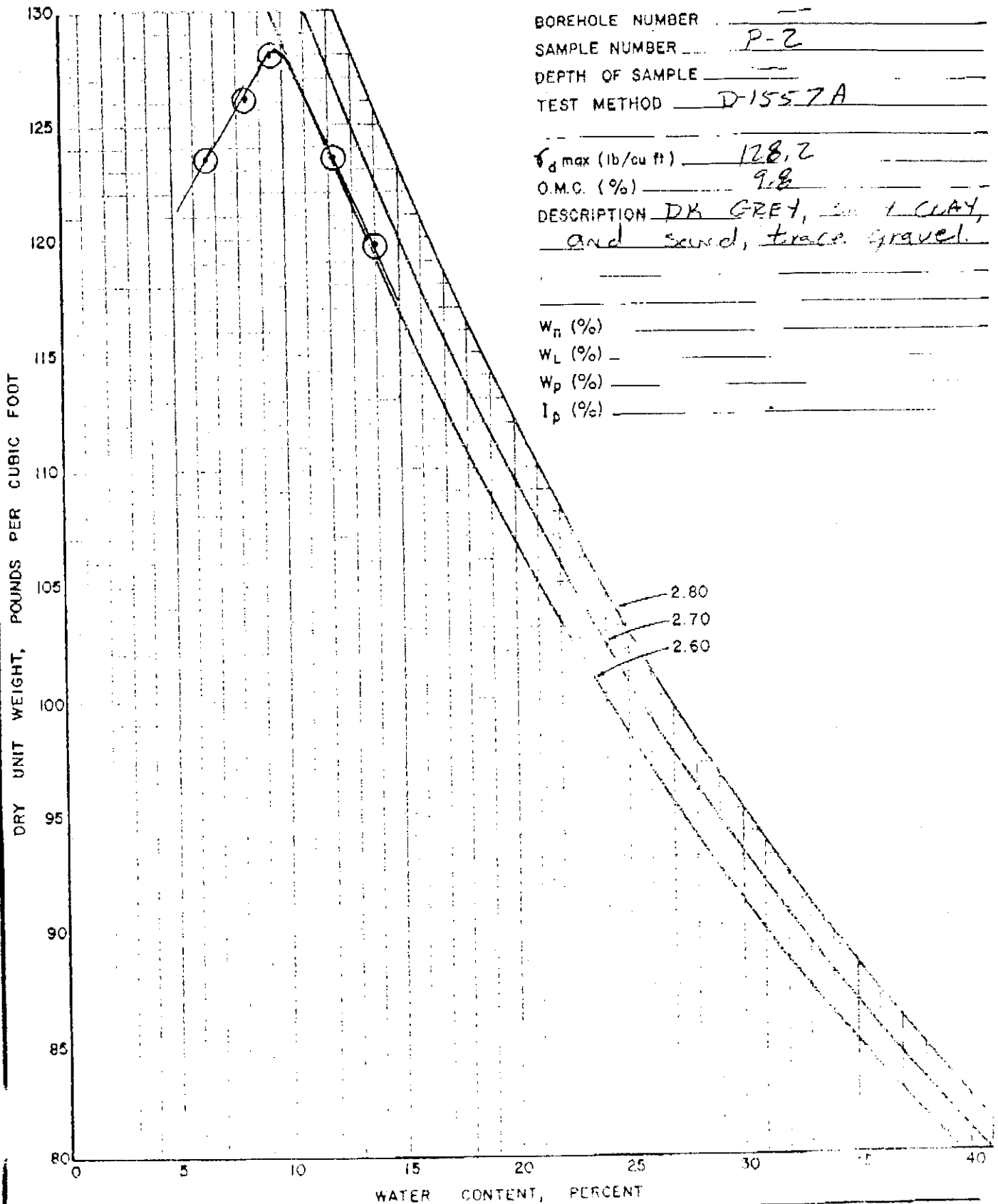
Date 7/3/90
Job No. 903-3078

Golder Associates

Drawn WMS
Checked _____
Reviewed _____

COMPACTION TEST RESULTS

CURVE 11



Date 6/25/90

Job No 903-3078

907-1045

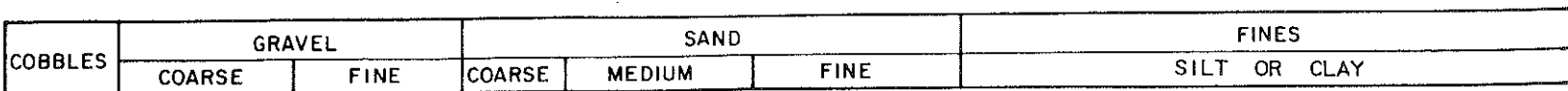
Golder Associates

Drawn WMS

Checked AKA

Approved _____

FIGURE



BORING NO.	ELEV. OR DEPTH	W _n	W _L	W _p	I _p	DESCRIPTION OR CLASSIFICATION
P-2	—	13.90	25	13	12	DK. GREY, SILTY CLAY, some sand trace gravel (CL)

Golder Associates

Drawn WMS
Checked _____
Reviewed _____



MOISTURE - DENSITY RELATIONS

PROJECT: Allen Park Clay Mine - Cell II

PROJECT NO.: 89365 OW

LOCATION: Allen Park, Michigan

DATE: 8/16/89

SUPPLIER/SOURCE: I-696 Brown Clay and Native Gray Clay

TESTED BY: JKR

SAMPLE LOCATION: Cell II Floor

CHECKED BY: MS

METHOD OF COMPACTION: ASTM D-1557 Method A

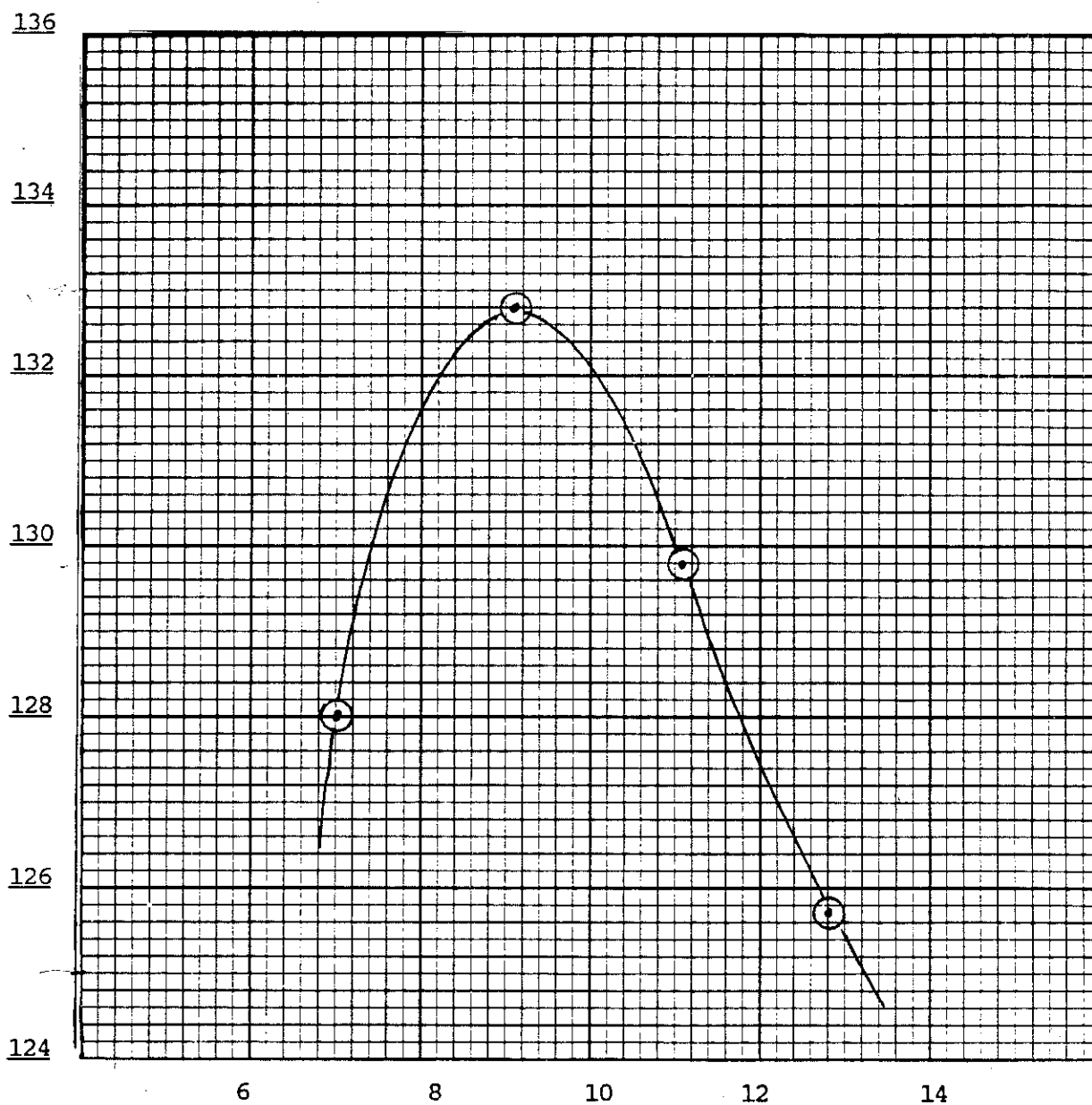
LAB SAMPLE NO.: 6461/6462

MOLD NO.: A VOLUME: 0.0330 CUBIC FEET MATERIAL DESIGNATION NO.: Bag 100

SAMPLE DESCRIPTION: Brown and Gray SILTY CLAY with Trace of Sand and Gravel

MAXIMUM DRY DENSITY: 132.8 PCF

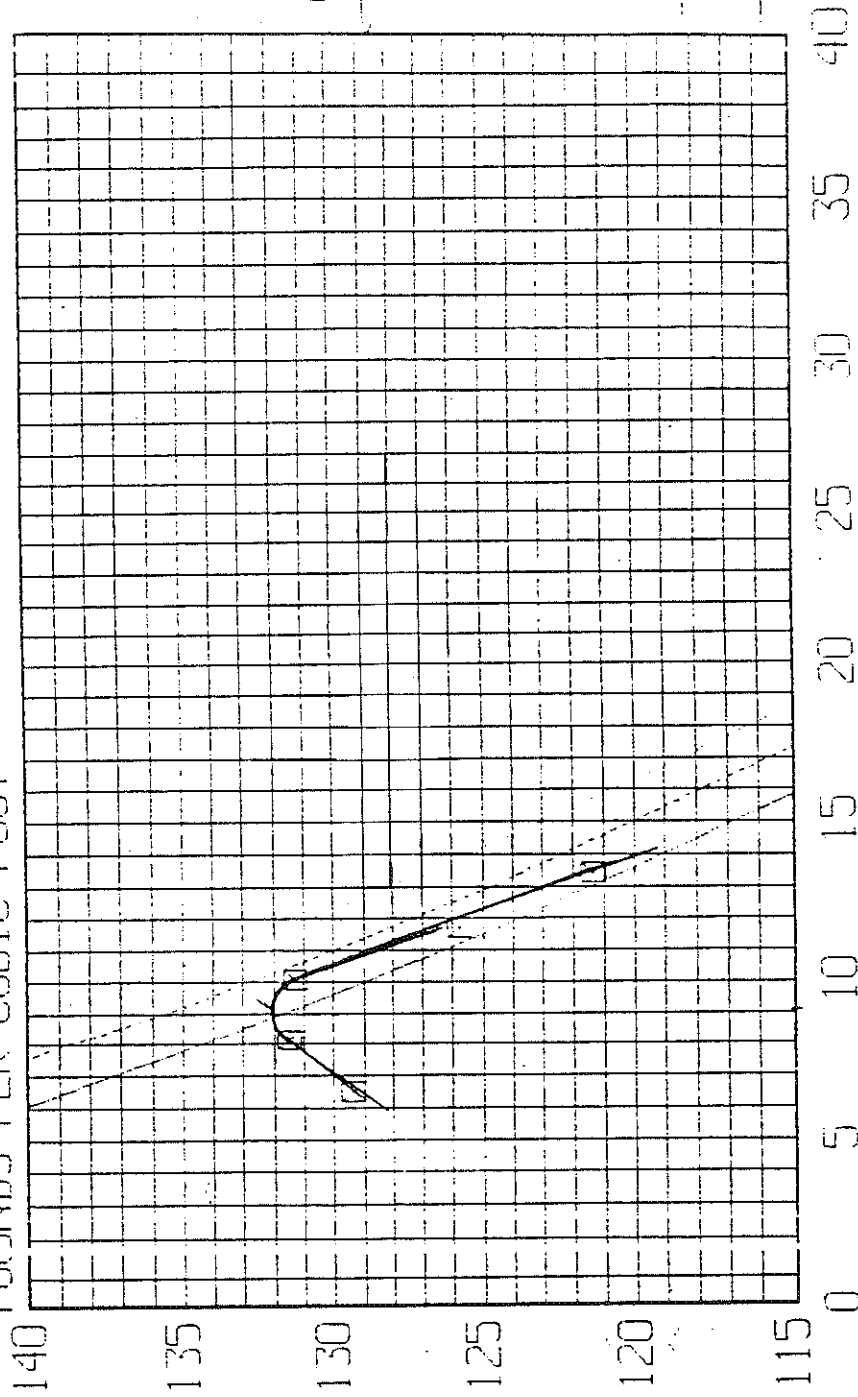
OPTIMUM MOISTURE CONTENT: 9.1 %



COMPACTION TEST

DRY UNIT WEIGHT,
POUNDS PER CUBIC FOOT

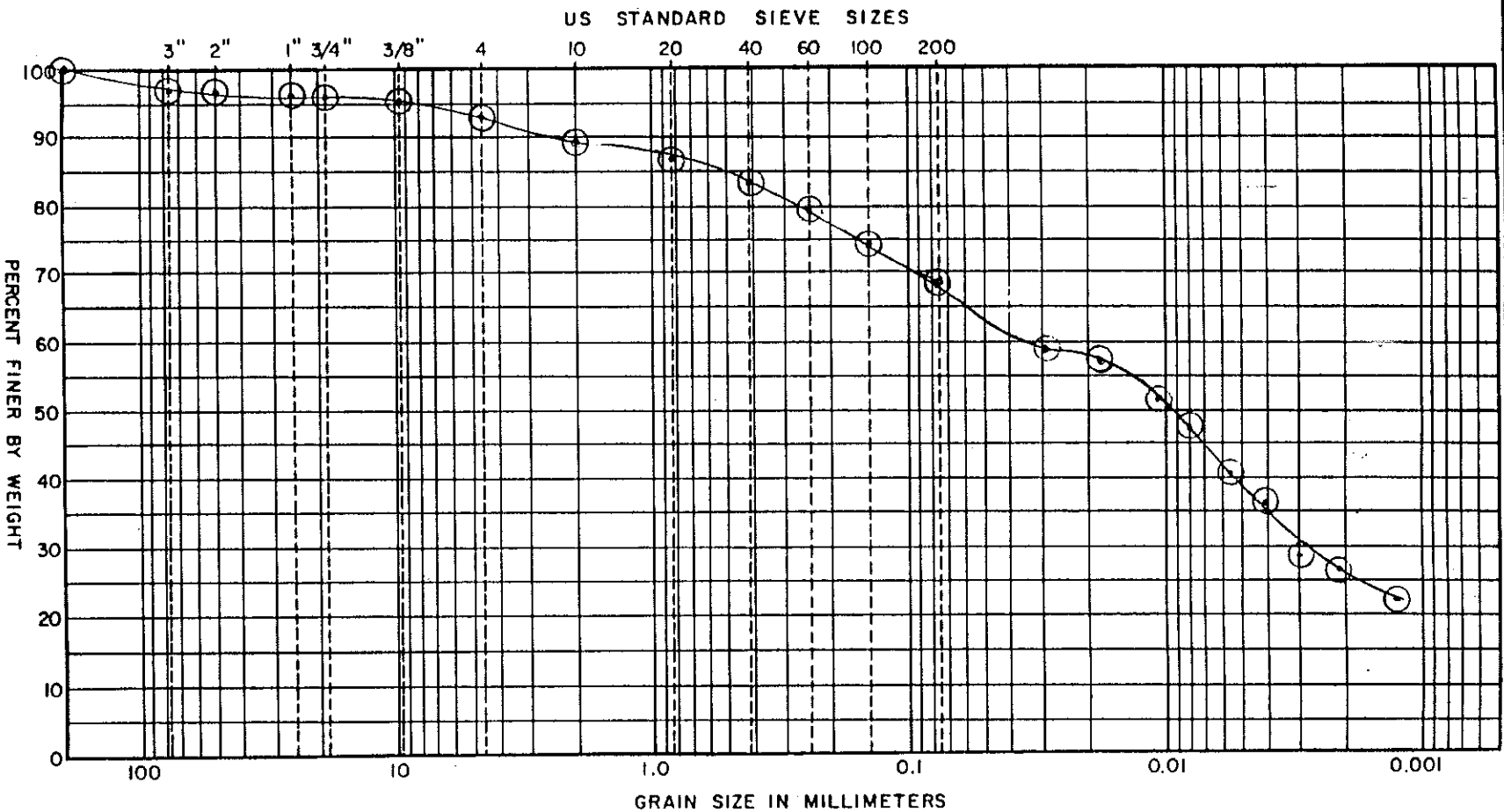
5/14/92



WATER CONTENT (%)

GRAIN SIZE DISTRIBUTION

FIGURE



COBBLES	GRAVEL		SAND			FINES	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO.	ELEV. OR DEPTH	w_n	w_L	w_p	I_p	DESCRIPTION OR CLASSIFICATION
L-1	—	9.21	25	14	11	Gray, SILTY CLAY, some of sand, trace of gravel + trace cobbles (CL)

Date 5/20/92
Job No. IC3-3755

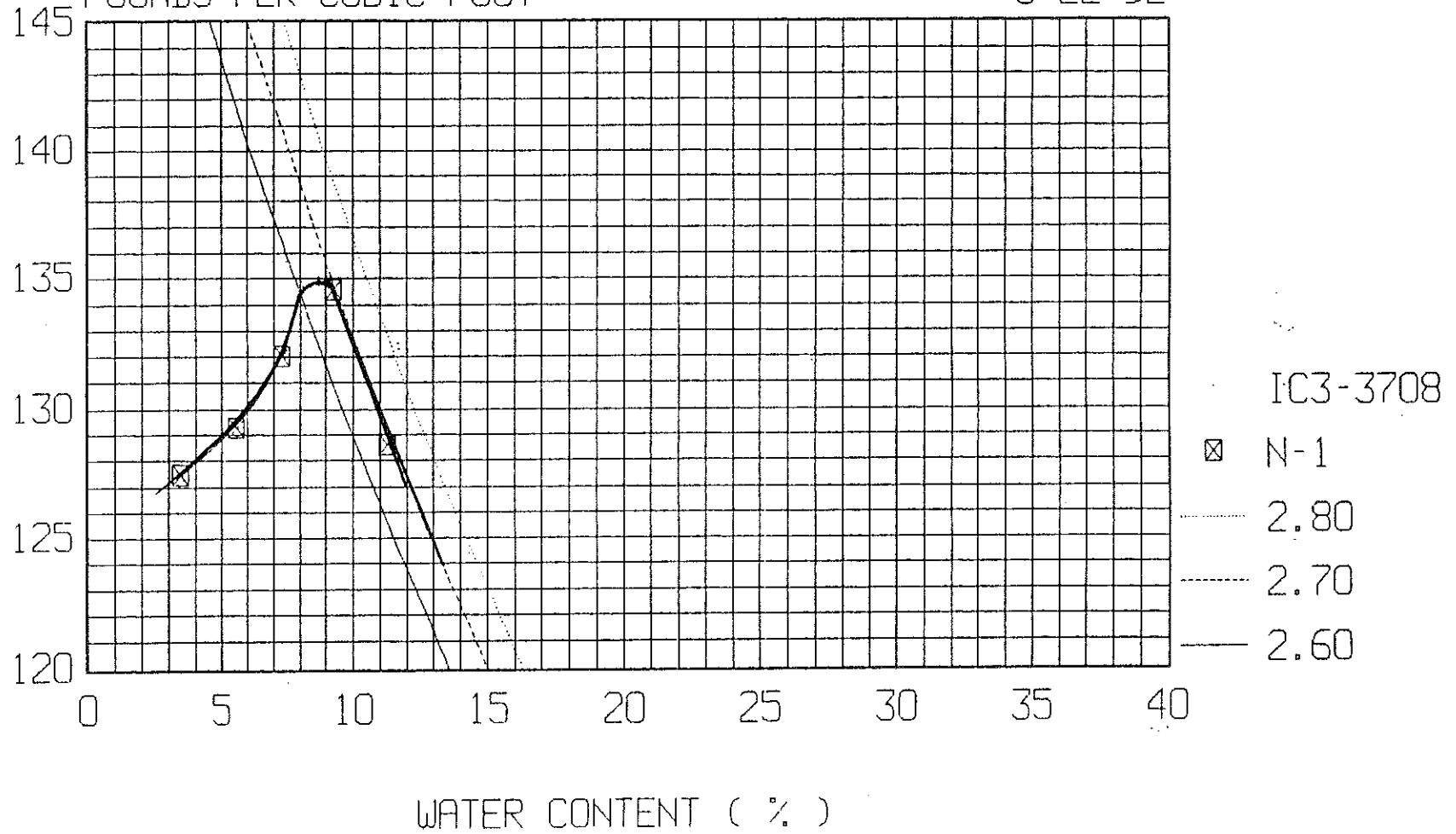
Golder Associates

Drawn MT
Checked WJF
Reviewed WJF

COMPACTION TEST

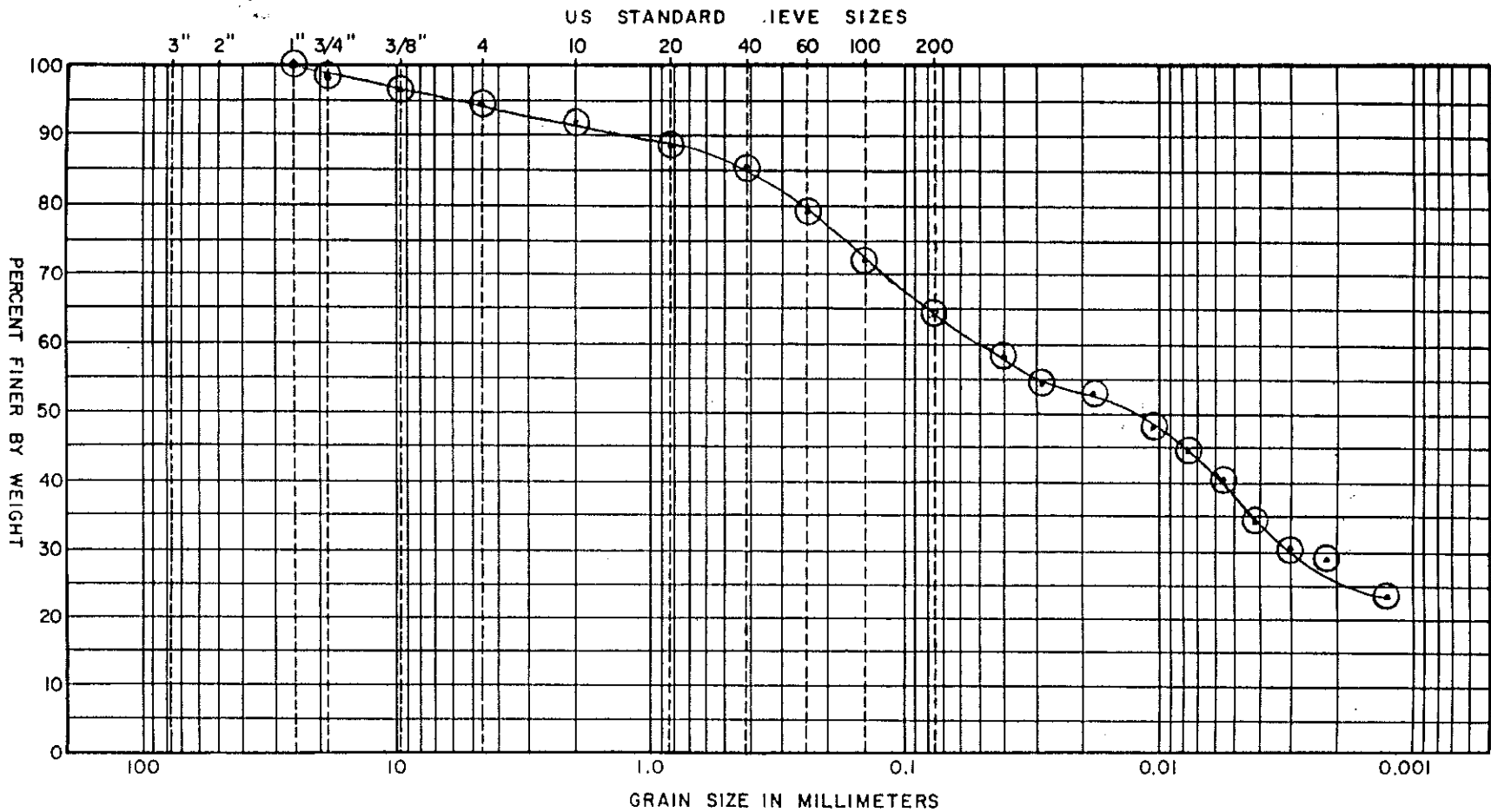
DRY UNIT WEIGHT,
POUNDS PER CUBIC FOOT

5/22/92



GRAIN SIZE DISTRIBUTION

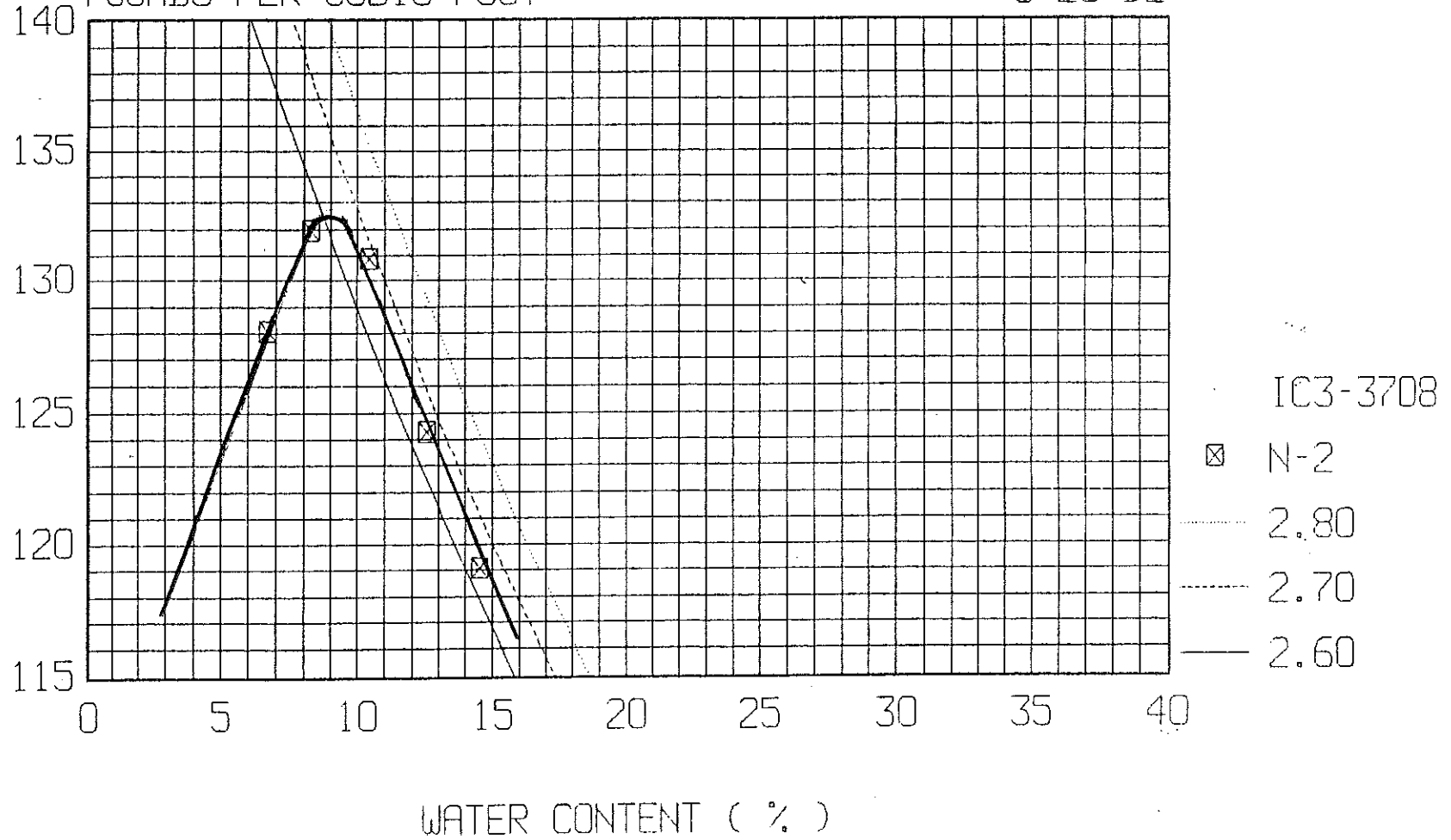
FIGURE



COMPACTION TEST

DRY UNIT WEIGHT,
POUNDS PER CUBIC FOOT

6/25/92



CURVE 15

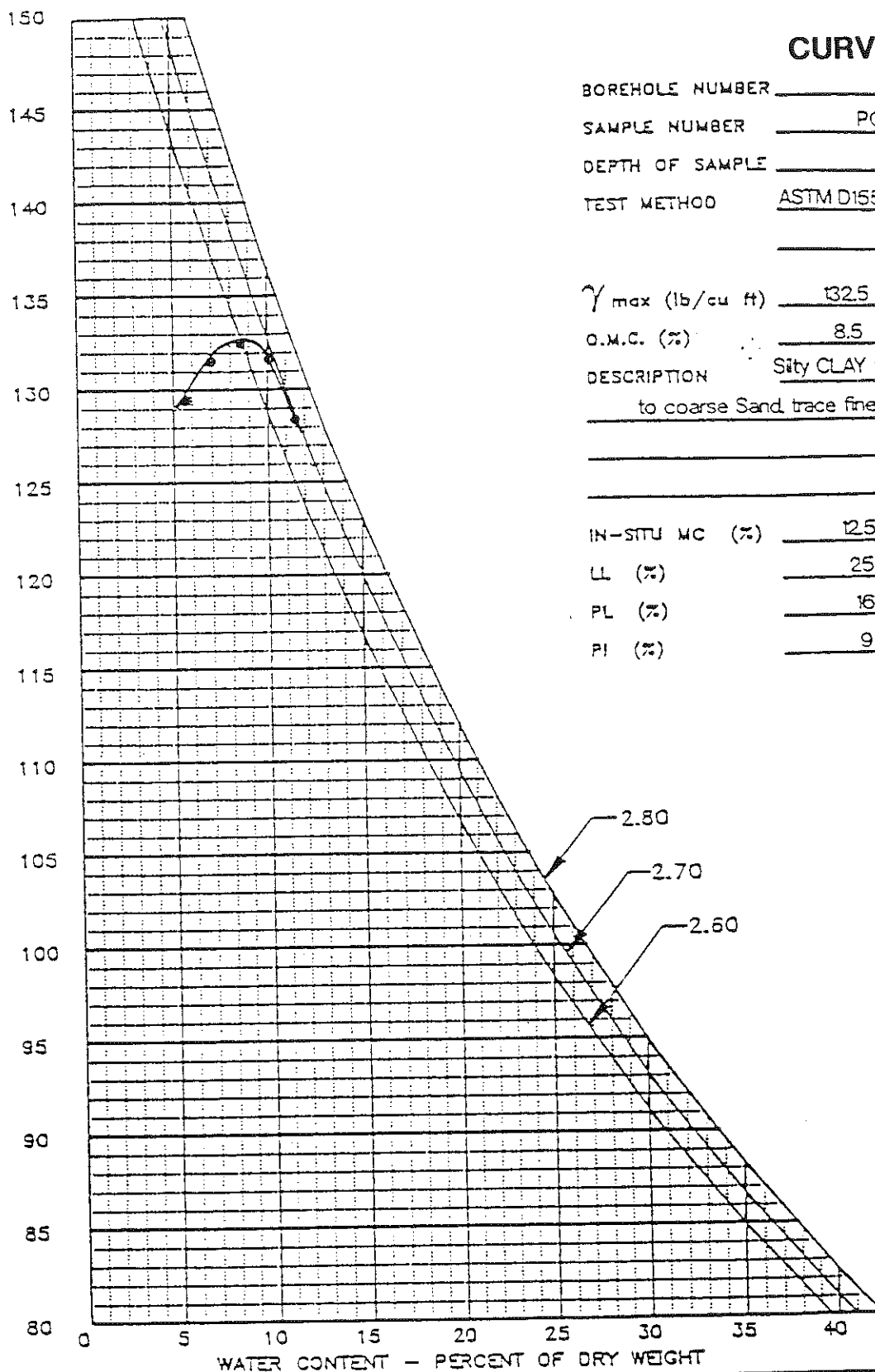
Golder Associates

Drawn WMS
Checked WMS
Reviewed _____

FIGURE

BORING NO.	ELEV. OR DEPTH	W _n	W _L	W _p	I _p	DESCRIPTION OR CLASSIFICATION
N-2	—	10.29	26	14	12	Greyish Brown, <u>SILTY CLAY</u> , some c-f sand, little c-f gravel (CL)

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



CURVE 16

BOREHOLE NUMBER _____

SAMPLE NUMBER PC-1

DEPTH OF SAMPLE _____

TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 132.5

O.M.C. (%) 8.5

DESCRIPTION Silty CLAY with some fine to coarse Sand, trace fine gravel (CL)

IN-SITU MC (%) 12.5

LL (%) 25

PL (%) 16

PI (%) 9

WATER CONTENT - PERCENT OF DRY WEIGHT



Golder Associates

Denver, Colorado

CLIENT/PROJECT

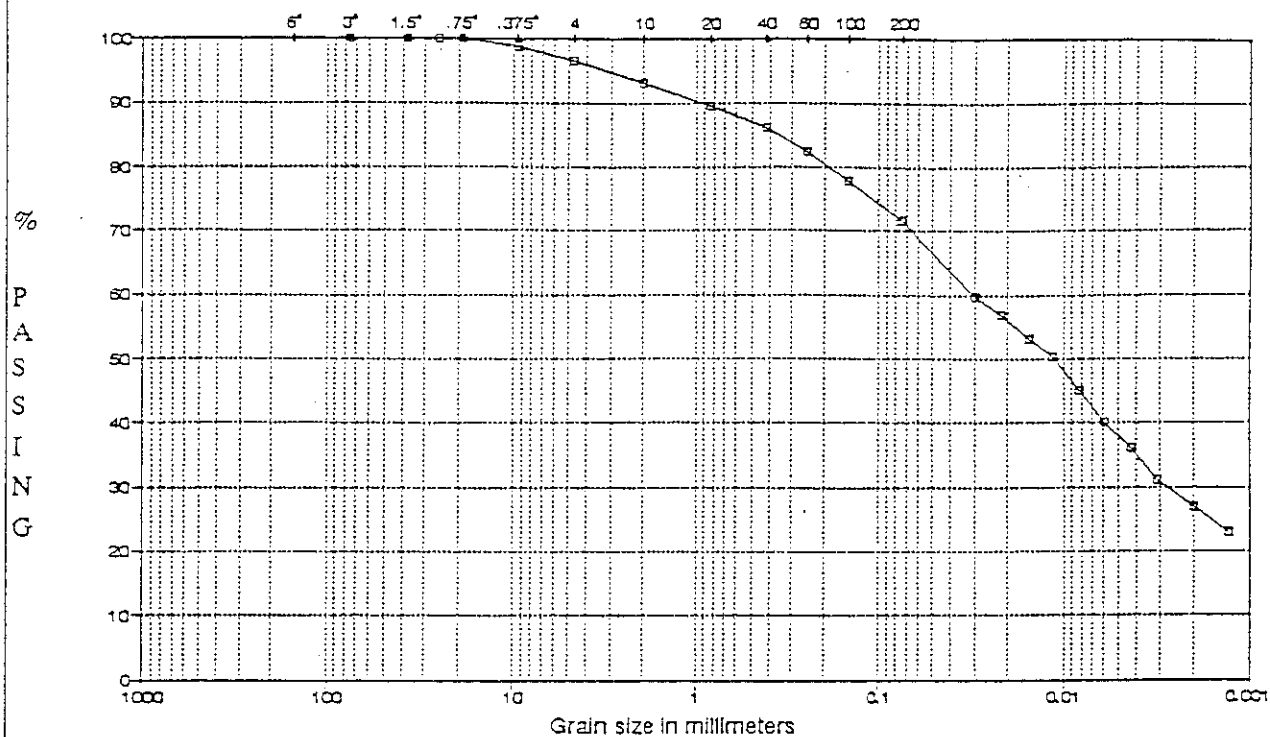
GCS/917-1203/MI

TITLE

**PROCTOR CURVE
PC-1**

DRAWN	CG	DATE	AUG 1992	JOB NO.
CHECKED	TT	SCALE		DWG NO./REV. NO.
REVIEWED		FILE NO.	WATER.DWG	FIGURE NO.

%	P A S S I N G
100	100
90	90
80	80
70	70
60	60
50	50
40	40
30	30
20	20
10	10
0	0



USCS

COBBLES	Coarse	Fine	Car	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	G _s	DESCRIPTION
BOREHOLE SAMPLE NO. PC-1 DEPTH	12.5	25	16	9	2.71	Silty CLAY with some fine to coarse sand, trace fine gravel
	Sample Type:	Date Tested: AUGUST 1992				USCS: CL

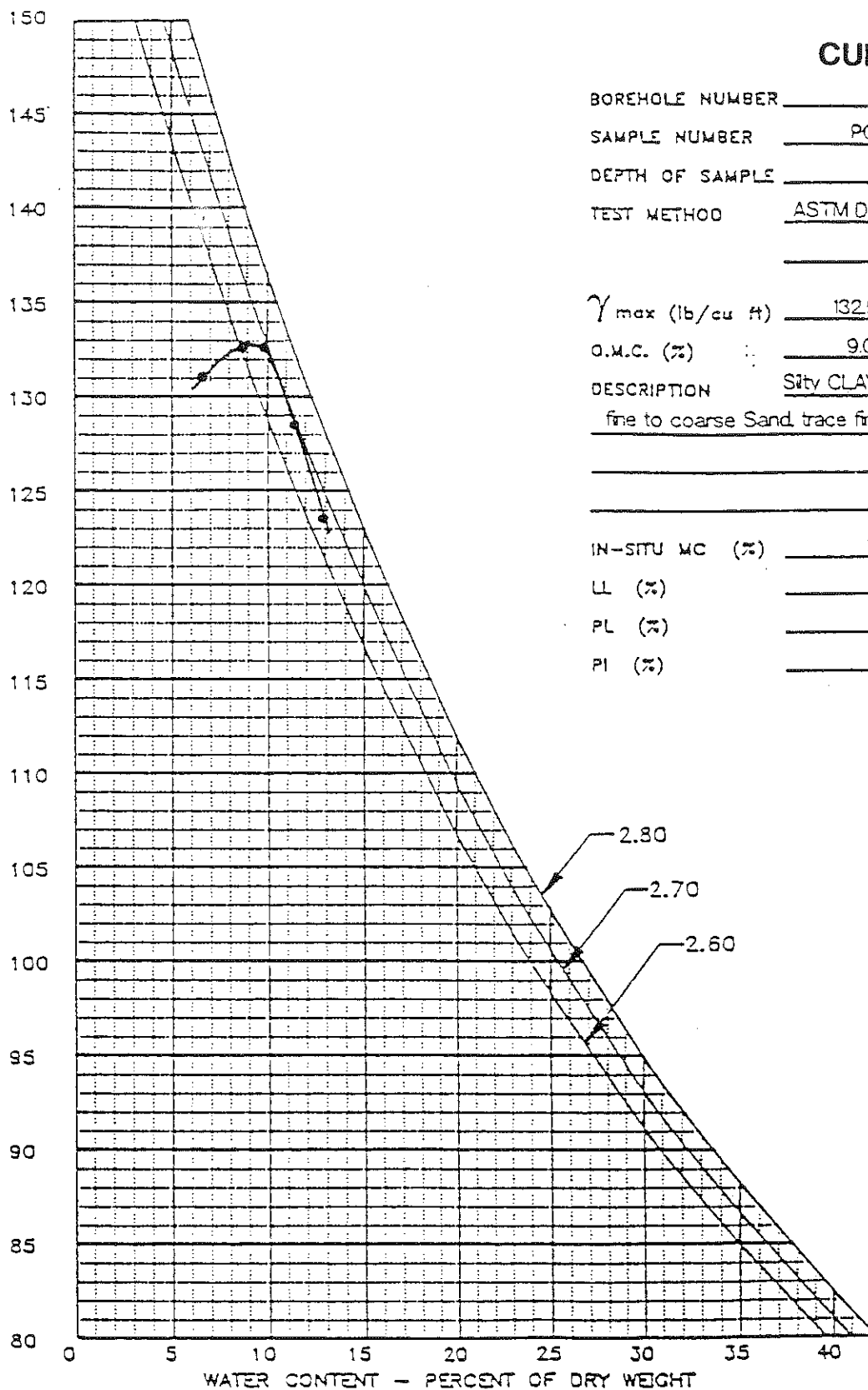
FORD/CELL 2/MI
IC3-2048

TECH: CG
DATE: 09/29/92
CHECKED: TT
REVIEWED:

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

FILENAME: 200001

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



CURVE 17

BOREHOLE NUMBER _____
SAMPLE NUMBER PC-2
DEPTH OF SAMPLE _____
TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 132.5
O.M.C. (%) 9.0
DESCRIPTION Silty CLAY with some fine to coarse Sand, trace fine gravel (CL)

IN-SITU MC (%) 13.9
LL (%) 26
PL (%) 15
PI (%) 11



Denver, Colorado

TITLE

PROCTOR CURVE
PC-2

CLIENT/PROJECT

GCS/917-1203/MI

DRAWN

CG

DATE

AUG 1992

JOB NO.

CHECKED

TT

SCALE

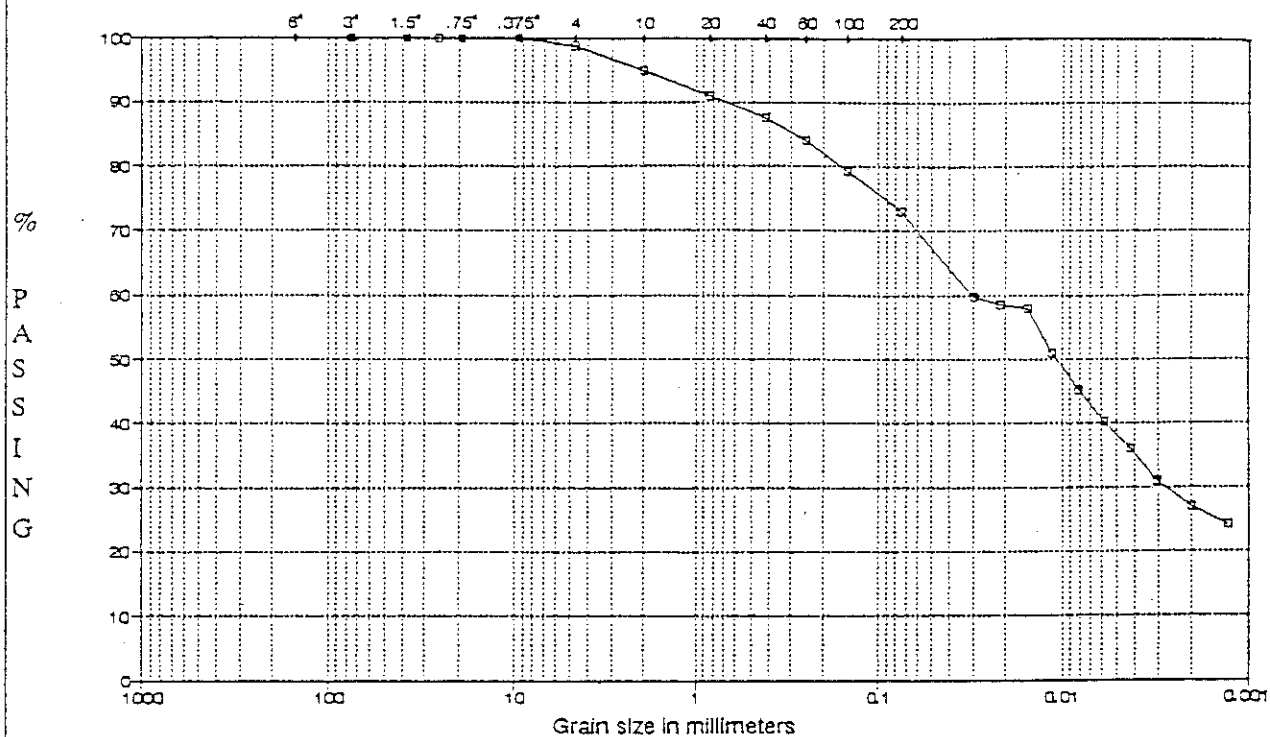
DWG NO./REV. NO.

REVIEWED

FILE NO. WATER.DWG

FIGURE NO.

%	PASSING
100	100
90	90
80	80
70	70
60	60
50	50
40	40
30	30
20	20
10	10
0	0



USCS

COBBLES	Coarse	Fine	Car	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-2 DEPTH	13.9	26	15	11	2.75	Silty CLAY with some fine to coarse sand, trace fine gravel
Sample Type:	Date Tested: AUGUST 1992				USCS: CL	

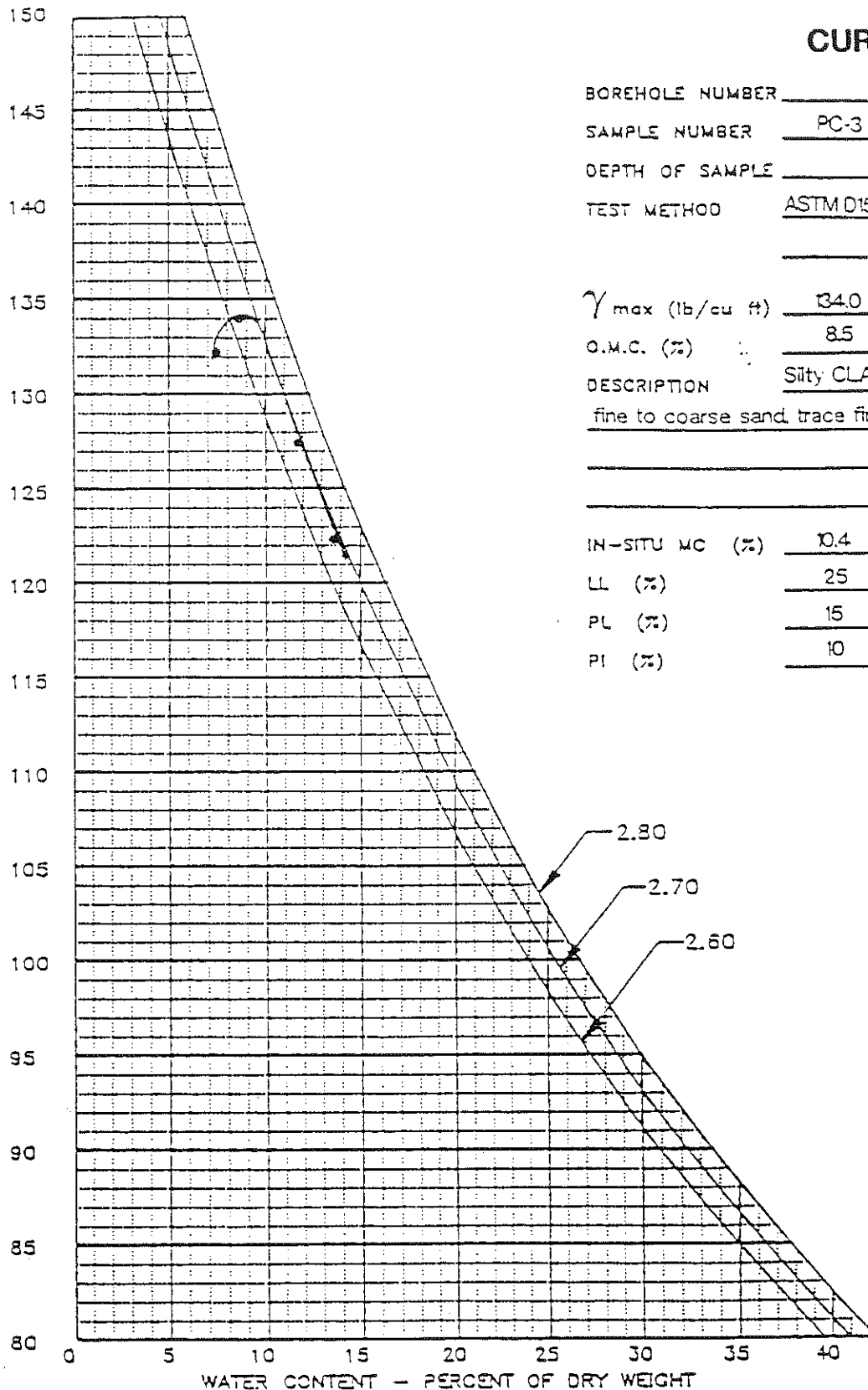
FORD/CELL 2/MI
IC3-2048

TECH: MS
DATE: 09/29/92
CHECKED: TT
REVIEWED:

FILENAME: SUPC

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



CURVE 18

BOREHOLE NUMBER _____

SAMPLE NUMBER PC-3

DEPTH OF SAMPLE _____

TEST METHOD ASTM D1557 METHOD C A

γ_{max} (lb/cu ft) 134.0

O.M.C. (%) 8.5

DESCRIPTION Silty CLAY with some fine to coarse sand, trace fine gravel (CL)

IN-SITU MC (%) 10.4

LL (%) 25

PL (%) 15

PI (%) 10



Denver, Colorado

TITLE

PROCTOR CURVE
PC-3

CLIENT/PROJECT

GCS/917-1203/MI

DRAWN

MS

DATE

AUG 1992

JOB NO.

ICG-2048

CHECKED

TT

SCALE

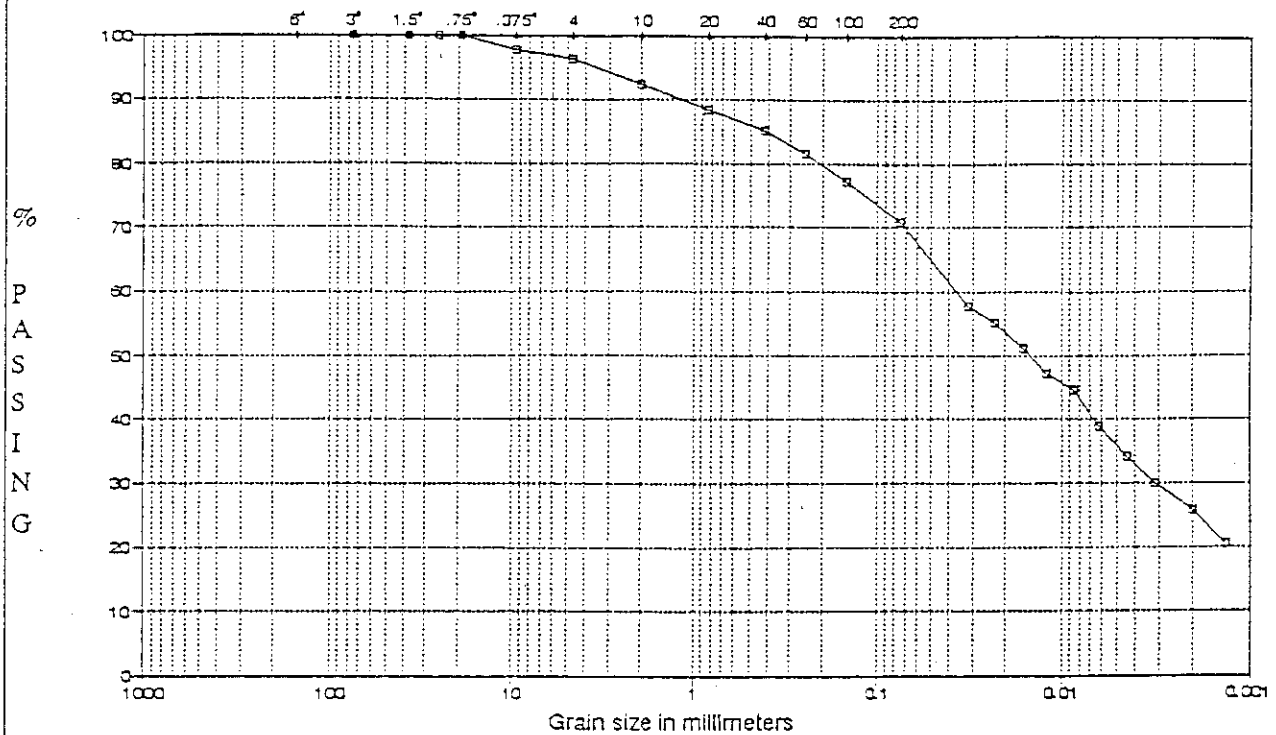
DWG NO./REV. NO.

REVIEWED

FILE NO.

FIGURE NO.

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS	COBBLES	Coarse	Fine	Coar	Med	Fine	FINES (Silt and Clay)
		GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-3 DEPTH	10.4	25	15	10	2.72	Silty CLAY with some fine to coarse sand, trace fine gravel

Sample Type:	Date Tested: AUGUST 1992	USCS: CL
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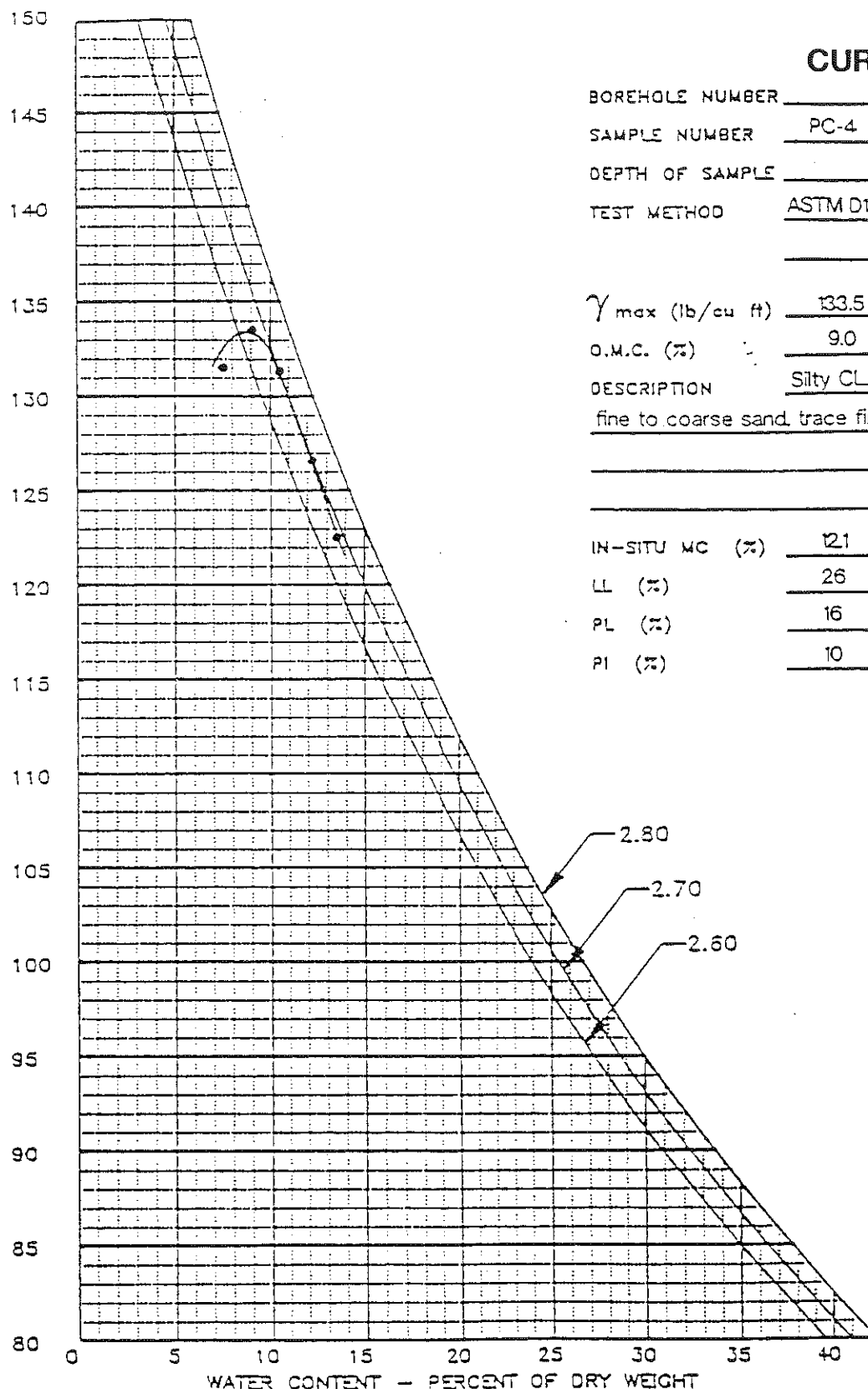
TECH: CG
DATE: 09/29/92
CHECKED: TT
REVIEWED:

GCS/917-1203/MI
IC3-2048

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

FILENAME: D422

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



CURVE 19

BOREHOLE NUMBER _____
 SAMPLE NUMBER PC-4
 DEPTH OF SAMPLE _____
 TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 133.5
 O.M.C. (%) 9.0
 DESCRIPTION Silty CLAY with some
fine to coarse sand, trace fine gravel (CL)

IN-SITU MC (%) 121
 LL (%) 26
 PL (%) 16
 PI (%) 10



**Golder
Associates**

Denver, Colorado

TITLE

**PROCTOR CURVE
PC-4**

CLIENT/PROJECT

GCS/917-1203/MI

DRAWN MS

DATE AUG 1992

JOB NO. IC3-2048

CHECKED TT

SCALE

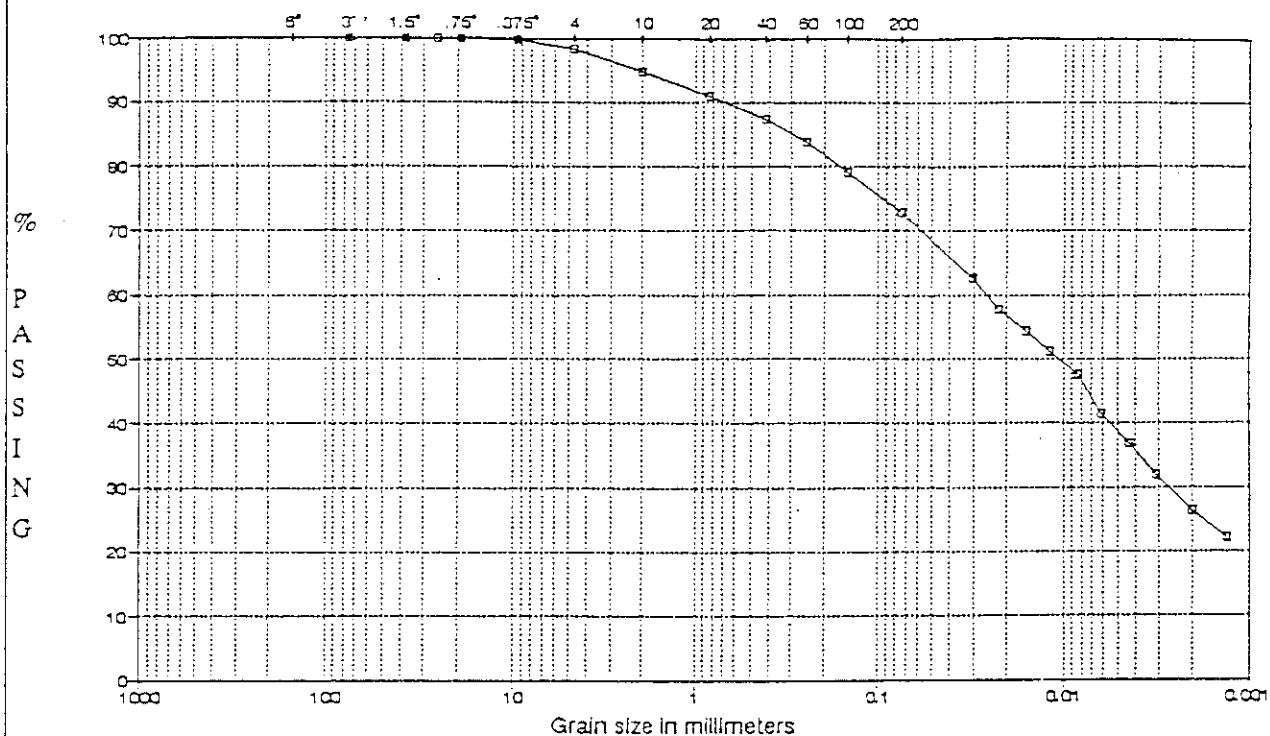
DWG NO./REV. NO.

REVIEWED

FILE NO.

FIGURE NO.

PASSING	%
100	100
90	90
80	80
70	70
60	60
50	50
40	40
30	30
20	20
10	10
0	0



USCS

COBBLES	Coarse	Fine	Cor	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-4 DEPTH	12.1	26	16	10	2.72	Silty CLAY with some fine to coarse sand, trace fine gravel
	Sample Type:	Date Tested: AUGUST 1992			USCS: CL	

GCS/917-1203/MI
IC3-2048

TECH: CG
DATE: 09/29/92
CHECKED: TT
REVIEWED:

FILENAME 34804

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

CURVE 20

BOREHOLE NUMBER _____

SAMPLE NUMBER PC-5

DEPTH OF SAMPLE _____

TEST METHOD ASTM D1557 METHOD C D A

γ_{max} (lb/cu ft) 130.5

O.M.C. (%) 9.5

DESCRIPTION Silty CLAY with some fine to coarse sand, trace fine gravel (CL)

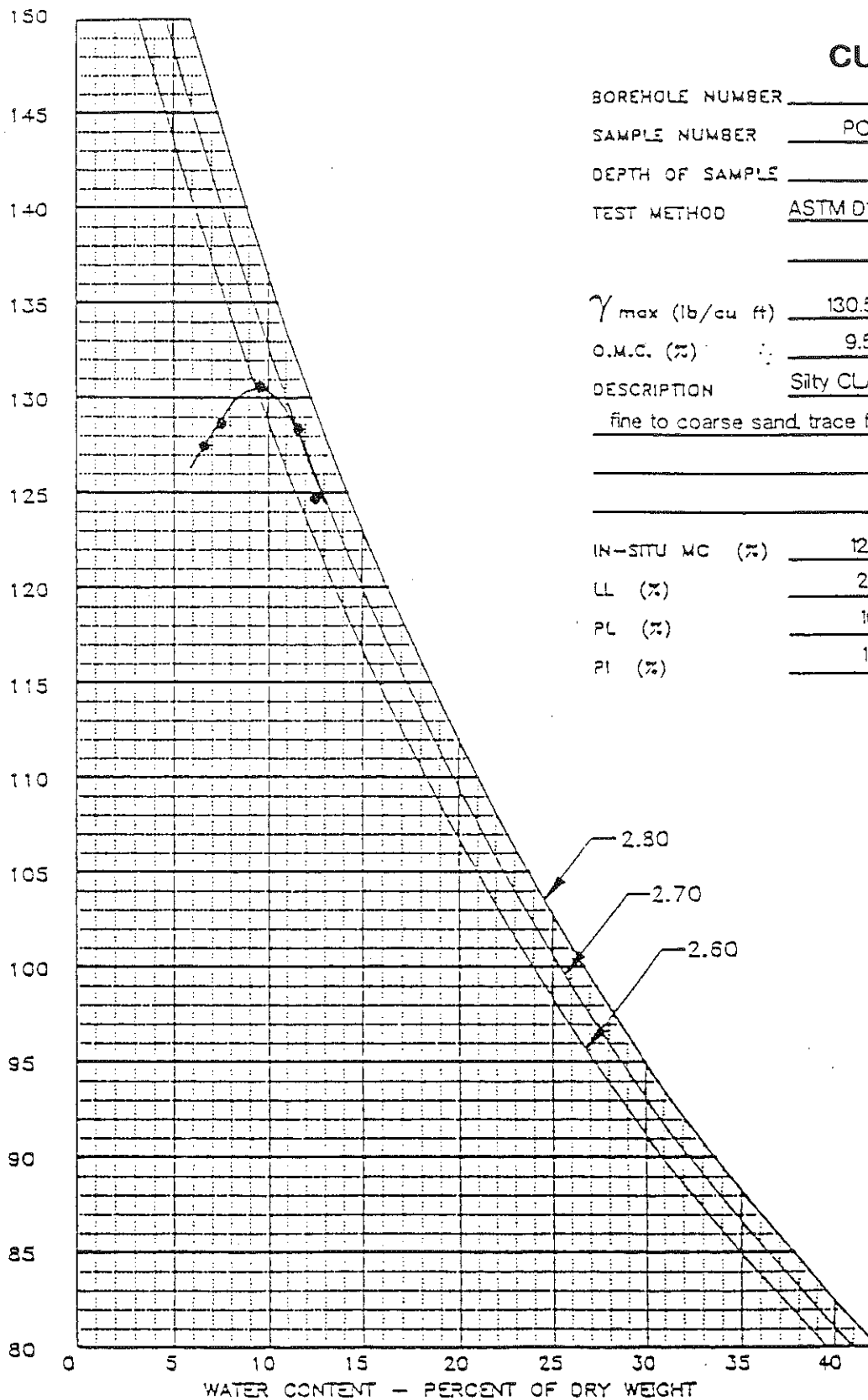
IN-SITU MC (%) 12.4

LL (%) 26

PL (%) 16

PI (%) 10

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



Golder Associates

Denver, Colorado

TITLE

**PROCTOR CURVE
PC-5**

CLIENT/PROJECT

GCS/927-1203/MI

DRAWN MS

DATE AUG 1992

LOG NO. IC3-2048

CHECKED TT

SCALE

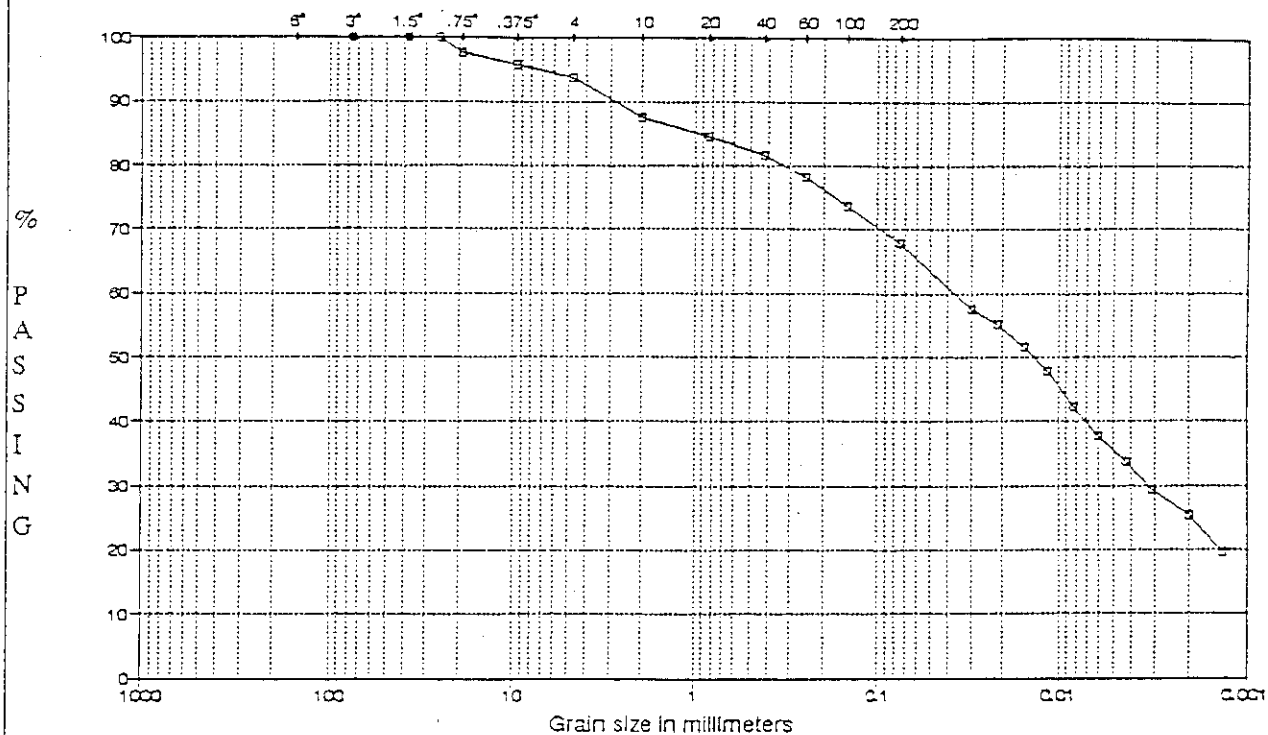
DWG NO./REV. NO.

REVIEWED OR

FILE NO.

FIGURE NO.

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS	COBBLES	Coarse	Fine	Coar	Med	Fine	FINES (Silt and Clay)
		GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-5 DEPTH	12.4	26	16	10	2.77	Silty CLAY with some fine to coarse sand, trace fine gravel

Sample Type: _____ Date Tested: AUGUST 1992 USCS: CL

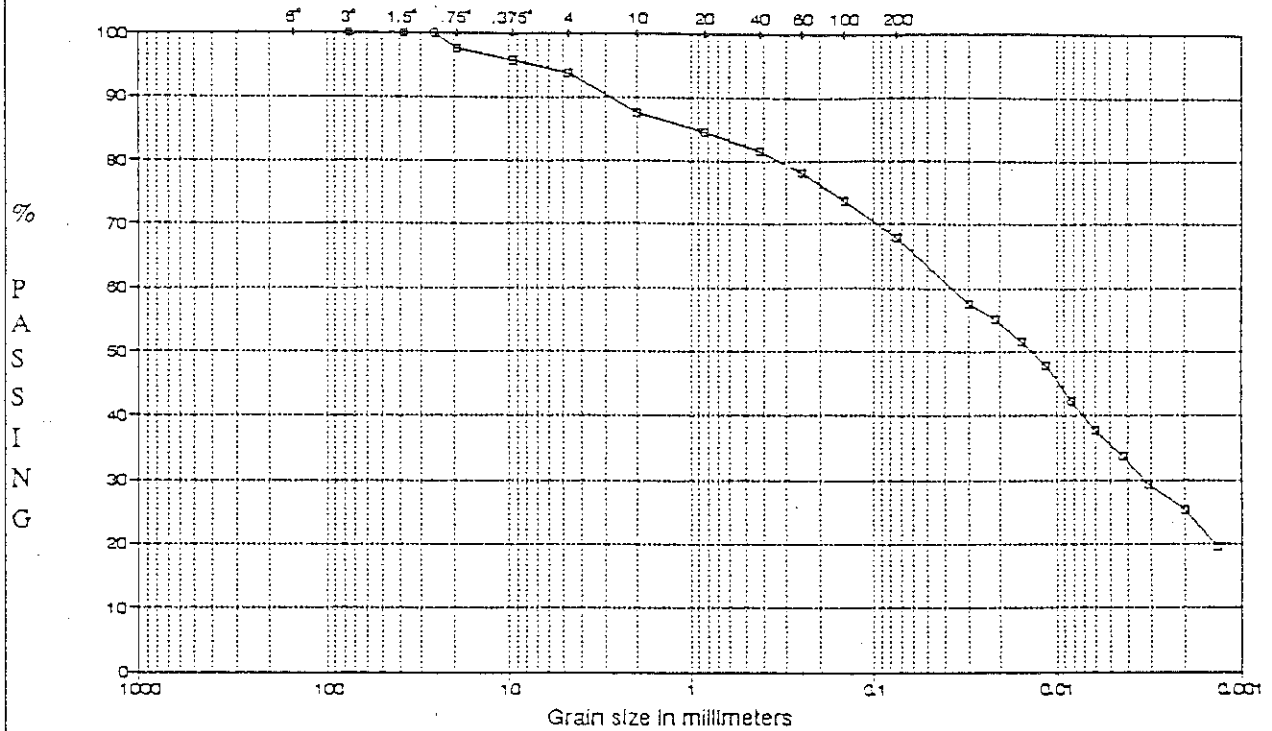
TECH: MS
DATE: 09/29/92
CHECKED: TT
REVIEWED:

FORD/CELL 2/MI
IC3-2048

FILENAME: 2440

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS

COBBLES	Coarse	Fine	Coar	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-5 DEPTH	12.4	26	16	10	2.77	Silty CLAY with some fine to coarse sand, trace fine gravel
Sample Type:		Date Tested: AUGUST 1992				USCS: CL

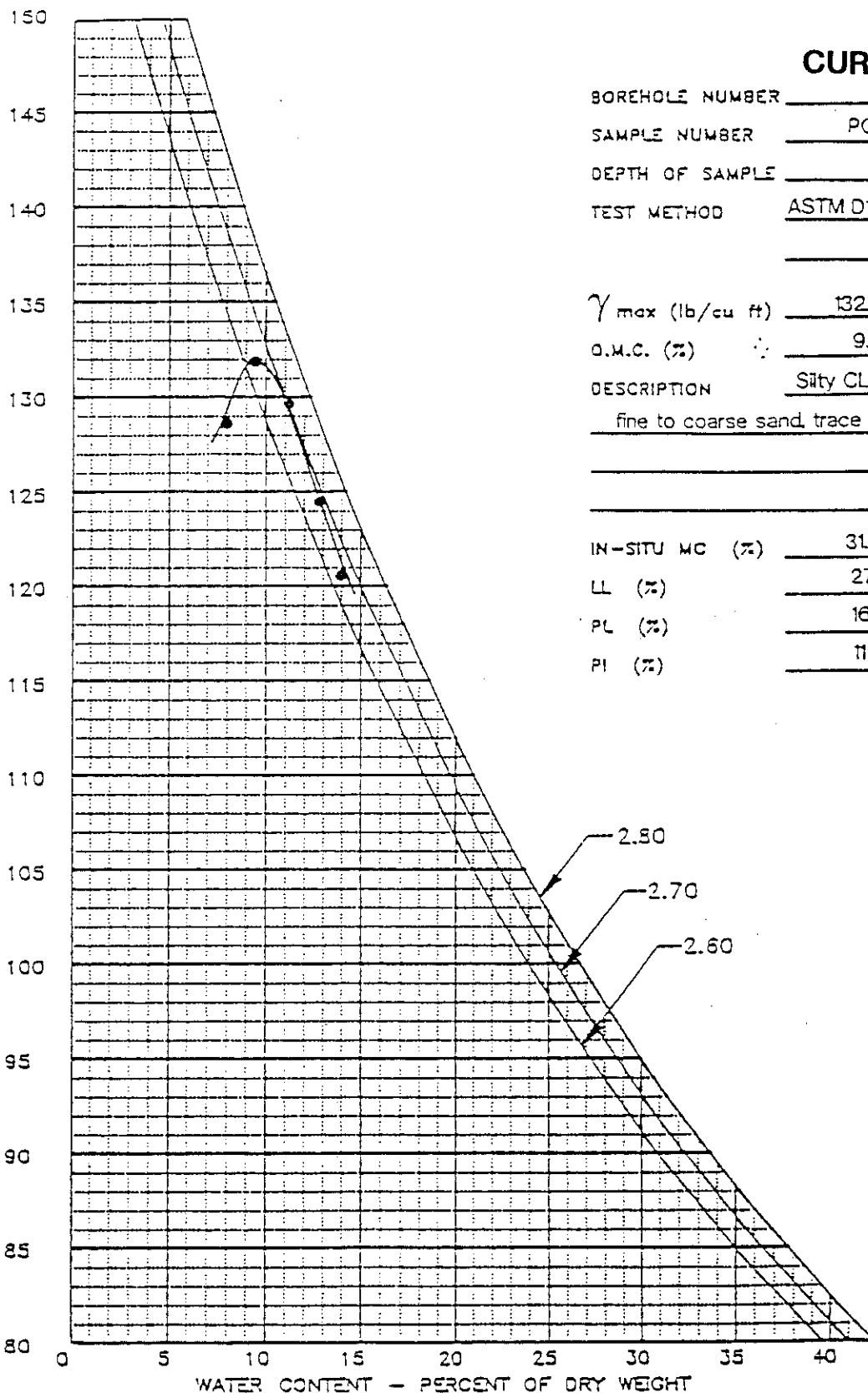
TECH: MS
DATE: 09/29/92
CHECKED: TT
REVIEWED:

FORD/CELL 2/MI
IC3-2048

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

FILENAME: D421

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



CURVE 21

BOREHOLE NUMBER _____
 SAMPLE NUMBER PC-7
 DEPTH OF SAMPLE _____
 TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 132.0
 O.M.C. (%) 9.5
 DESCRIPTION Silty CLAY with some
fine to coarse sand, trace fine gravel (CL)

IN-SITU MC (%) 31.3
 LL (%) 27
 PL (%) 16
 PI (%) 11



**Golder
Associates**

Denver, Colorado

TITLE

**PROCTOR CURVE
PC-7**

CLIENT/PROJECT

GCS/927-1203/MI

DRAWN

CG

DATE

AUG 1992

JOB NO.

IC3-2048

CHECKED

TT

SCALE

DWG NO./REV. NO.

REVIEWED

DR

FILE NO.

FIGURE NO.

The graph plots the percentage of material passing (Y-axis, 0 to 100) against grain size in millimeters (X-axis, logarithmic scale from 1000 to 0.001). The curve starts at 100% for grain sizes of 6 mm and above, then drops to approximately 90% at 10 mm, 80% at 1 mm, and continues to decrease to about 22% at 0.075 mm.

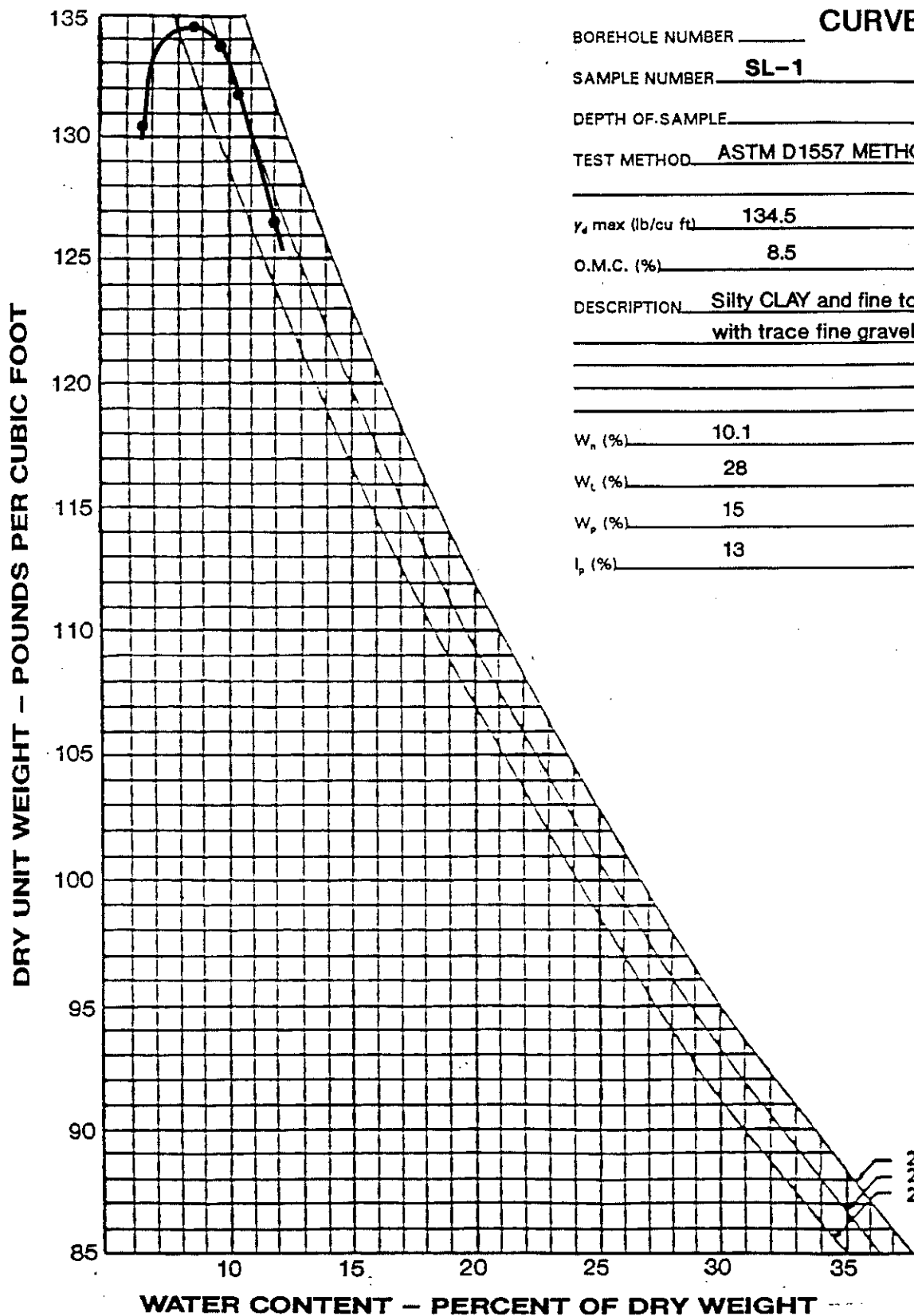
Grain size (mm)	Percentage passing (%)
6	100
3	100
1.5	100
0.75	100
0.375	98
0.25	95
0.15	90
0.1	87
0.075	84
0.05	80
0.0375	76
0.025	70
0.015	60
0.01	56
0.0075	53
0.005	50
0.00375	46
0.0025	42
0.0015	37
0.001	32
0.00075	28
0.0005	22

USCS	COBBLES	Coarse	Fine	Coar	Med	Fine	FINES (Silt and Clay)
		GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-7 DEPTH	11.8	27	16	11	2.73	Silty CLAY with some fine to coarse sand, trace fine gravel
Sample Type:	Date Tested: AUGUST 1992				USCS: CL	

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

FILENAME 34PCT



CURVE 22

BOREHOLE NUMBER _____

SAMPLE NUMBER **SL-1**

DEPTH OF SAMPLE _____

TEST METHOD **ASTM D1557 METHOD A**

γ_d max (lb/cu ft) **134.5**

O.M.C. (%) **8.5**

DESCRIPTION **Silty CLAY and fine to coarse SAND with trace fine gravel (CL).**

W_n (%) **10.1**

W_L (%) **28**

W_p (%) **15**

I_p (%) **13**

2.80
2.70
2.60



Golder Associates Inc.
Denver, Colorado

CLIENT/PROJECT

ECS/917-1203/MI

TITLE

**PROCTOR CURVE
SL-1**

DATE **JULY 1991**

SCALE **AS SHOWN**

JOB NO. **913-234**

DRAWN **MWB**

CHECKED **KMR**

REVIEWED **MES**

FILE

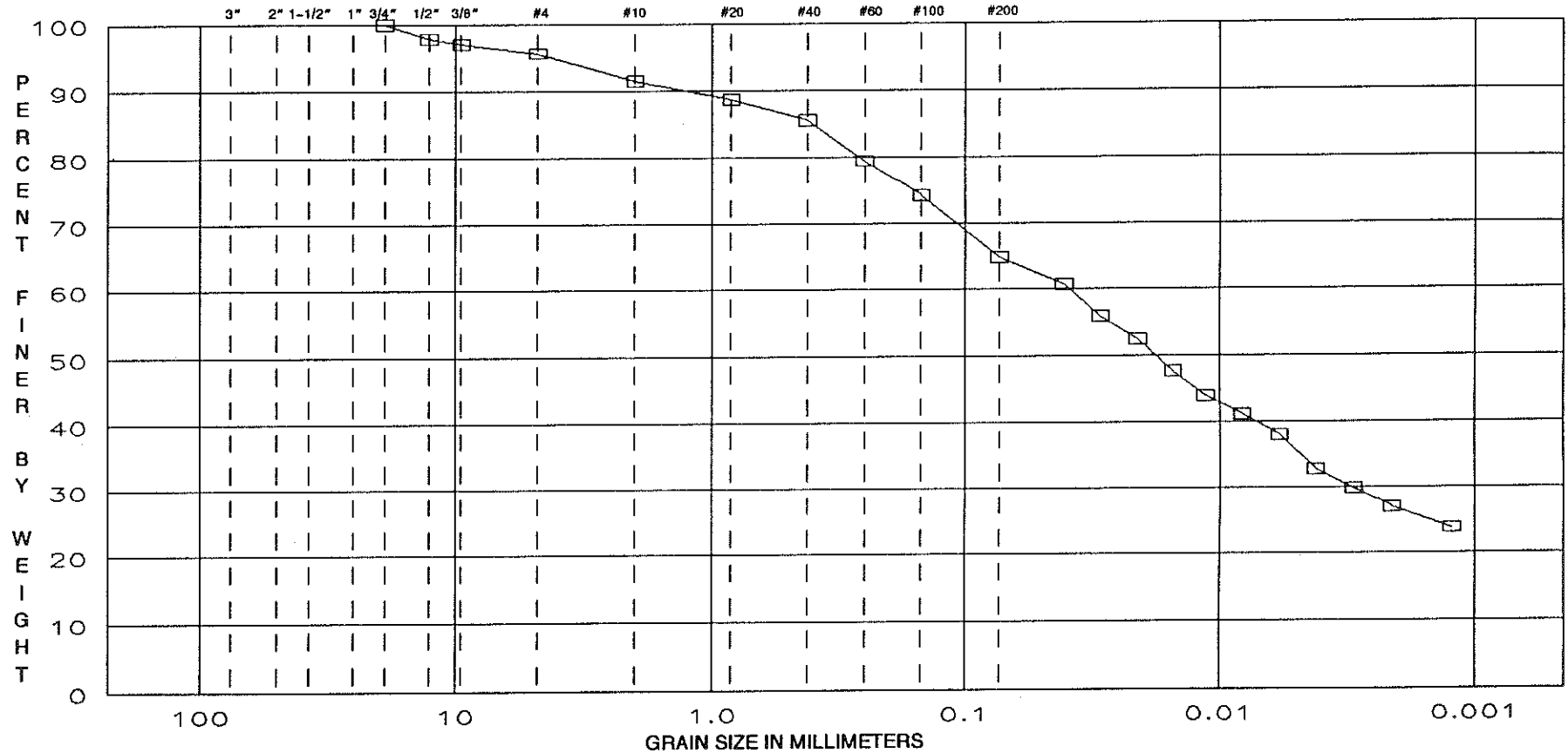
DWG. NO.

FIGURE

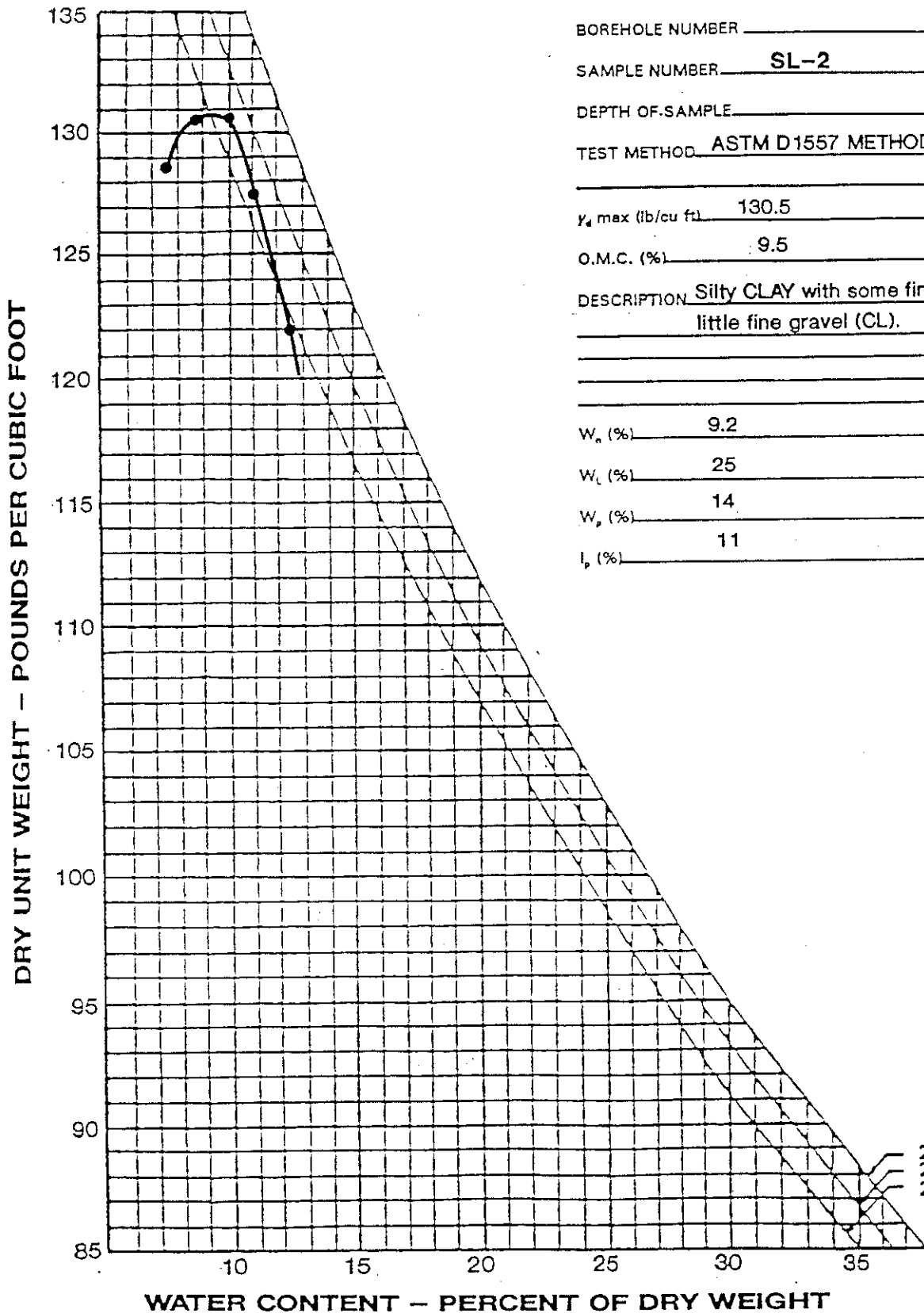
Requirement 225% passing - Sum.
~~225% passing~~

GRAIN SIZE DISTRIBUTION

US STANDARD SIEVE SIZES



CURVE 22A



BOREHOLE NUMBER _____

SAMPLE NUMBER SL-2

DEPTH OF SAMPLE _____

TEST METHOD ASTM D1557 METHOD A

$\gamma_d \text{ max (lb/cu ft)}$ 130.5

O.M.C. (%) 9.5

DESCRIPTION Silty CLAY with some fine to coarse sand,
little fine gravel (CL).

W_p (%) 9.2

W_L (%) 25

W_p (%) 14

I_p (%) 11

2.80
2.70
2.60



Golder Associates Inc.

Denver, Colorado

CLIENT/PROJECT

ECS/917-1203/MI

TITLE

PROCTOR CURVE
SL-2

DATE JULY 1991

SCALE AS SHOWN

JOB NO. 913-25-0

DRAWN TJS

CHECKED KMR

REVIEWED MES

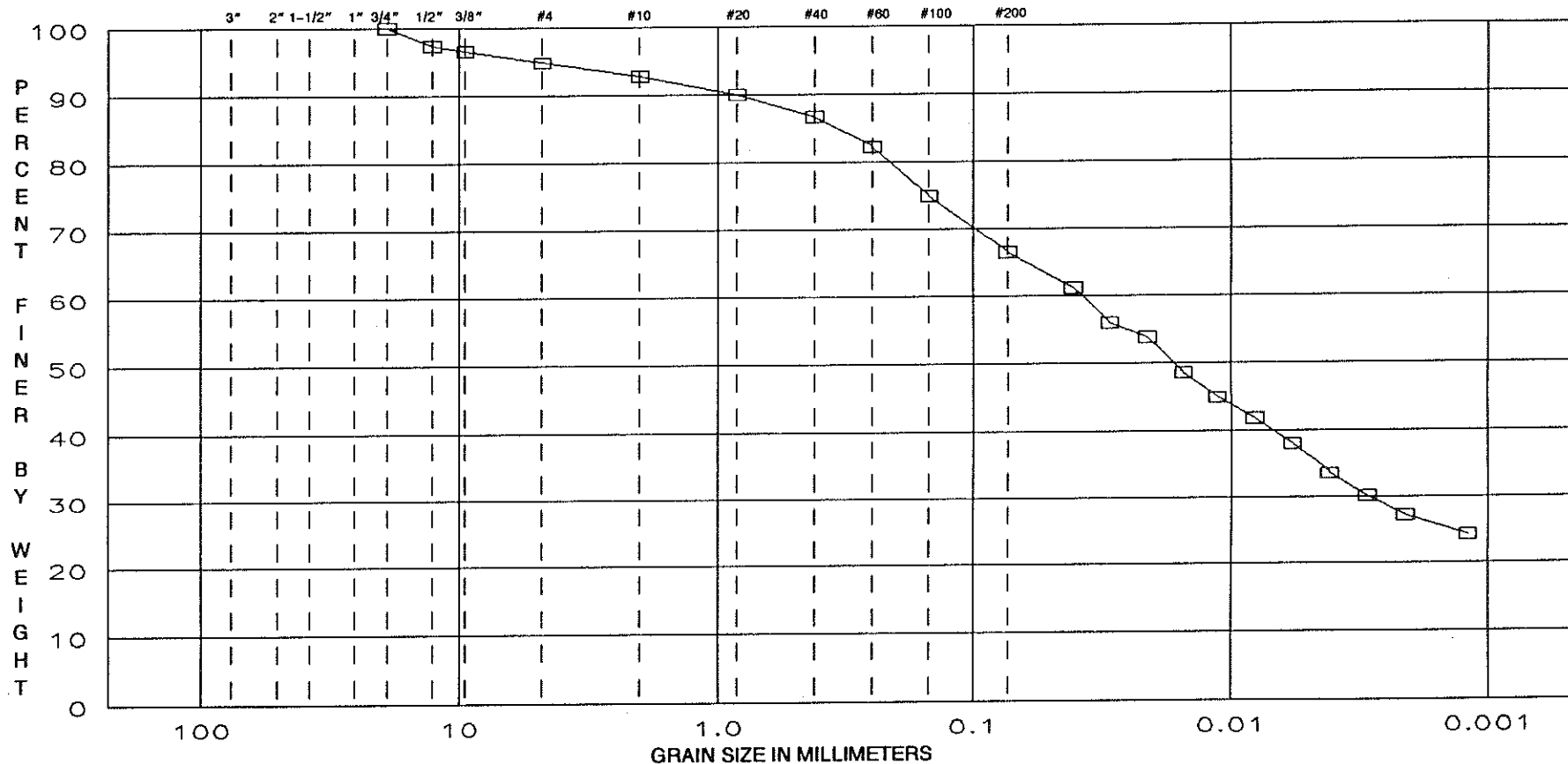
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DWG. NO.

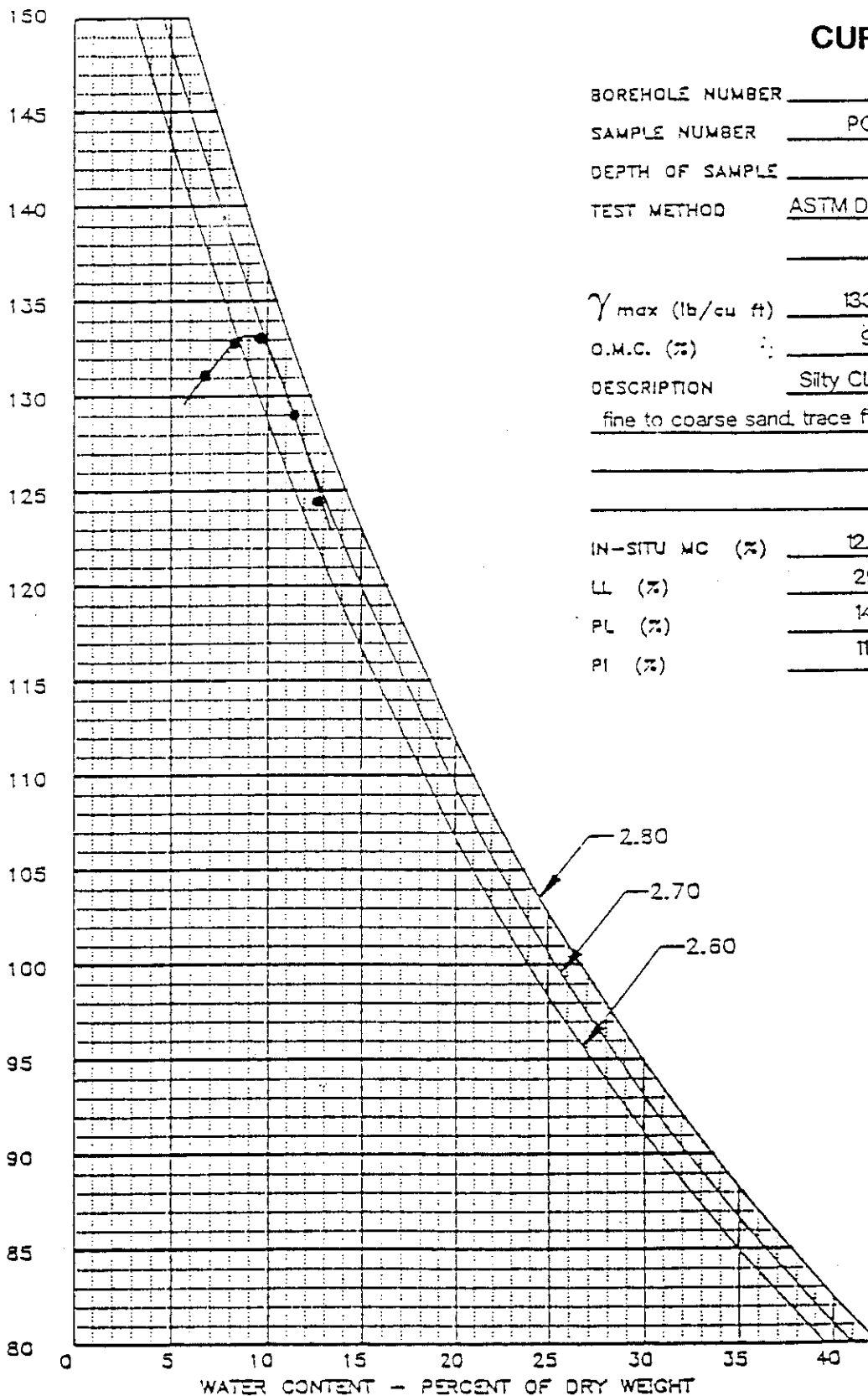
FIGURE

GRAIN SIZE DISTRIBUTION

US STANDARD SIEVE SIZES



DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



CURVE 23

BOREHOLE NUMBER _____
 SAMPLE NUMBER PC-9
 DEPTH OF SAMPLE _____
 TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 133.0
 O.M.C. (%) 9.0
 DESCRIPTION Silty CLAY with some
fine to coarse sand, trace fine gravel (CL)

IN-SITU MC (%) 12.0
 LL (%) 25
 PL (%) 14
 PI (%) 11



**Golder
Associates**

Denver, Colorado

CLIENT/PROJECT

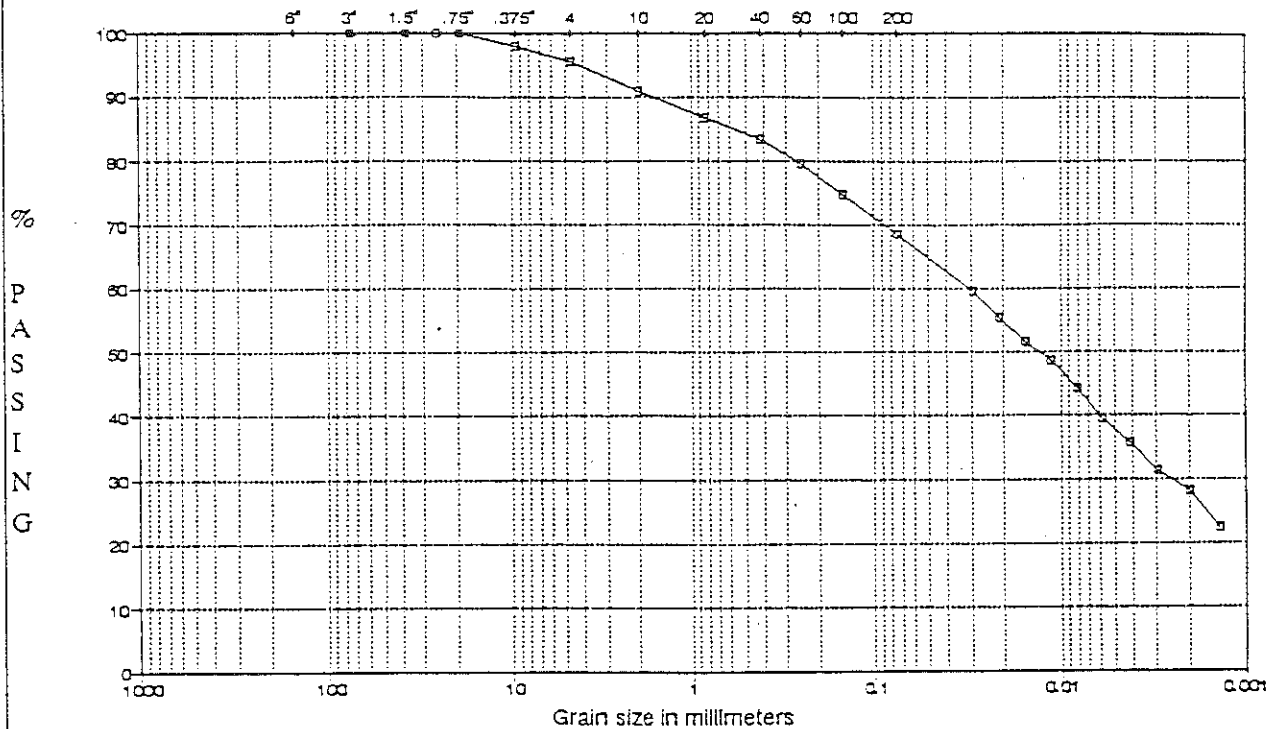
GCS/927-1203/MI

TITLE

**PROCTOR CURVE
PC-9**

DRAWN	CG	DATE	AUG 1992	JOB NO.	IC3-2048
CHECKED	TT	SCALE		DWG NO./REV. NO.	
REVIEWED	DR	FILE NO.		FIGURE NO.	

**PARTICLE SIZE DISTRIBUTION-ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS

COBBLES	Coarse	Fine	Gr	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-9 DEPTH	12.0	25	14	11	2.70	Silty CLAY with some fine to coarse sand, trace fine gravel

Sample Type:

Date Tested: SEPT 1992

USCS: CL

TECH: MS

DATE: 09/29/92

CHECKED: TT

REVIEWED: DR

FORD/CELL 2/MI
IC3-2048

FILENAME: DAP03

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

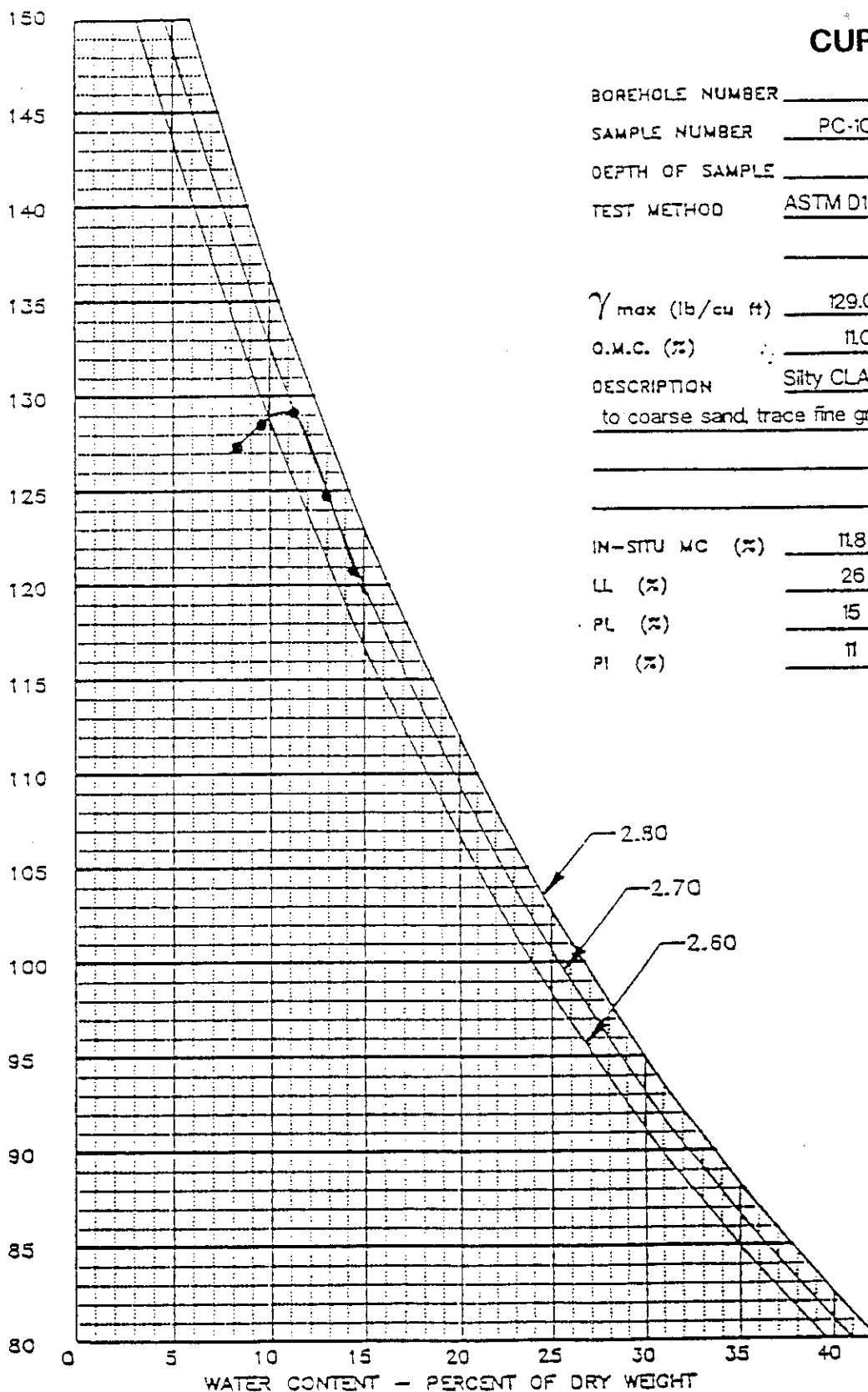
CURVE 24

BOREHOLE NUMBER _____
 SAMPLE NUMBER PC-10
 DEPTH OF SAMPLE _____
 TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 129.0
 O.M.C. (%) 11.0
 DESCRIPTION Silty CLAY with some fine to coarse sand, trace fine gravel (CL)

IN-SITU MC (%) 11.8
 LL (%) 26
 PL (%) 15
 PI (%) 11

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



Golder Associates

Denver, Colorado

TITLE

**PROCTOR CURVE
PC-10**

CLIENT/PROJECT

GCS/927-1203/MI

DRAWN CG

DATE AUG 1992

JOB NO. IC3-2048

CHECKED TT

SCALE

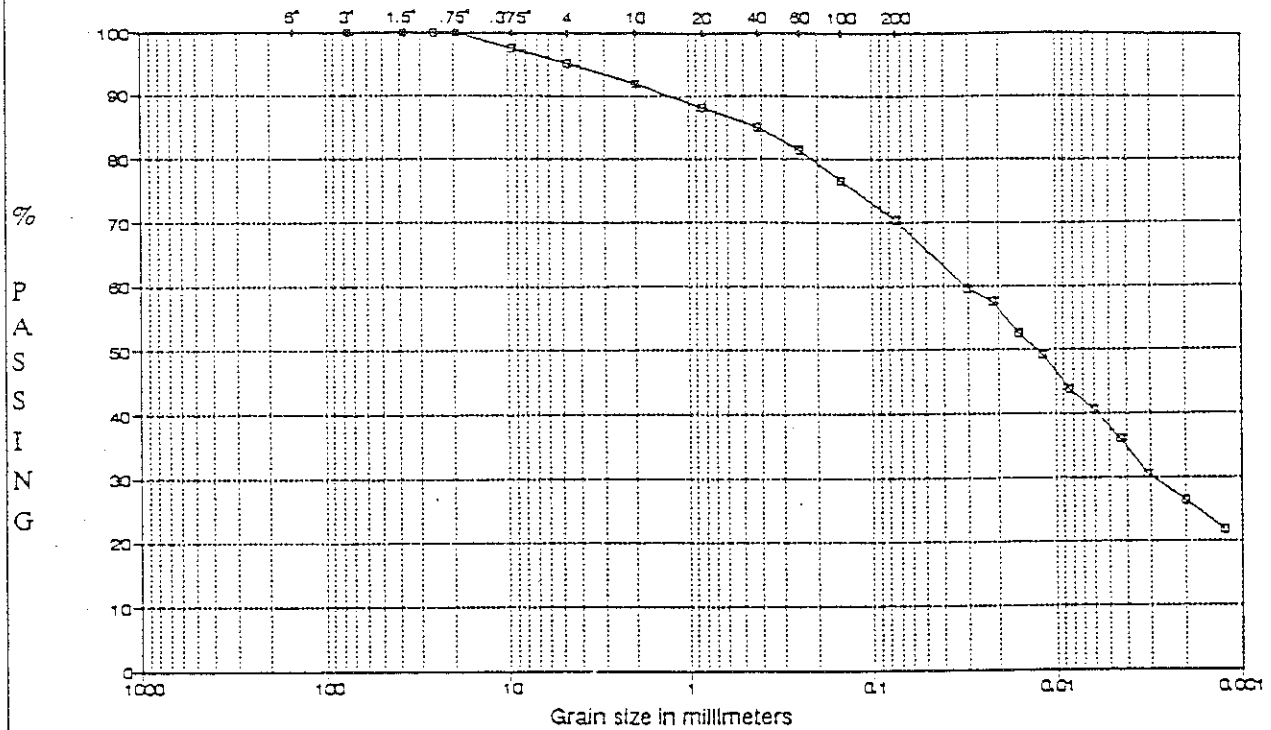
DWG NO./REV. NO.

REVIEWED DR

FILE NO.

FIGURE NO.

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS

COBBLES	Coarse	Fine	Co	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-10 DEPTH	11.8	26	15	11	2.73	Silty CLAY with some fine to coarse sand, trace fine gravel
Sample Type:		Date Tested: AUGUST 1992				USCS: CL

FORD/CELL 2/MI
IC3-2048

TECH: MS
DATE: 09/29/92
CHECKED: TT
REVIEWED: DR

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

FILENAME: 20480

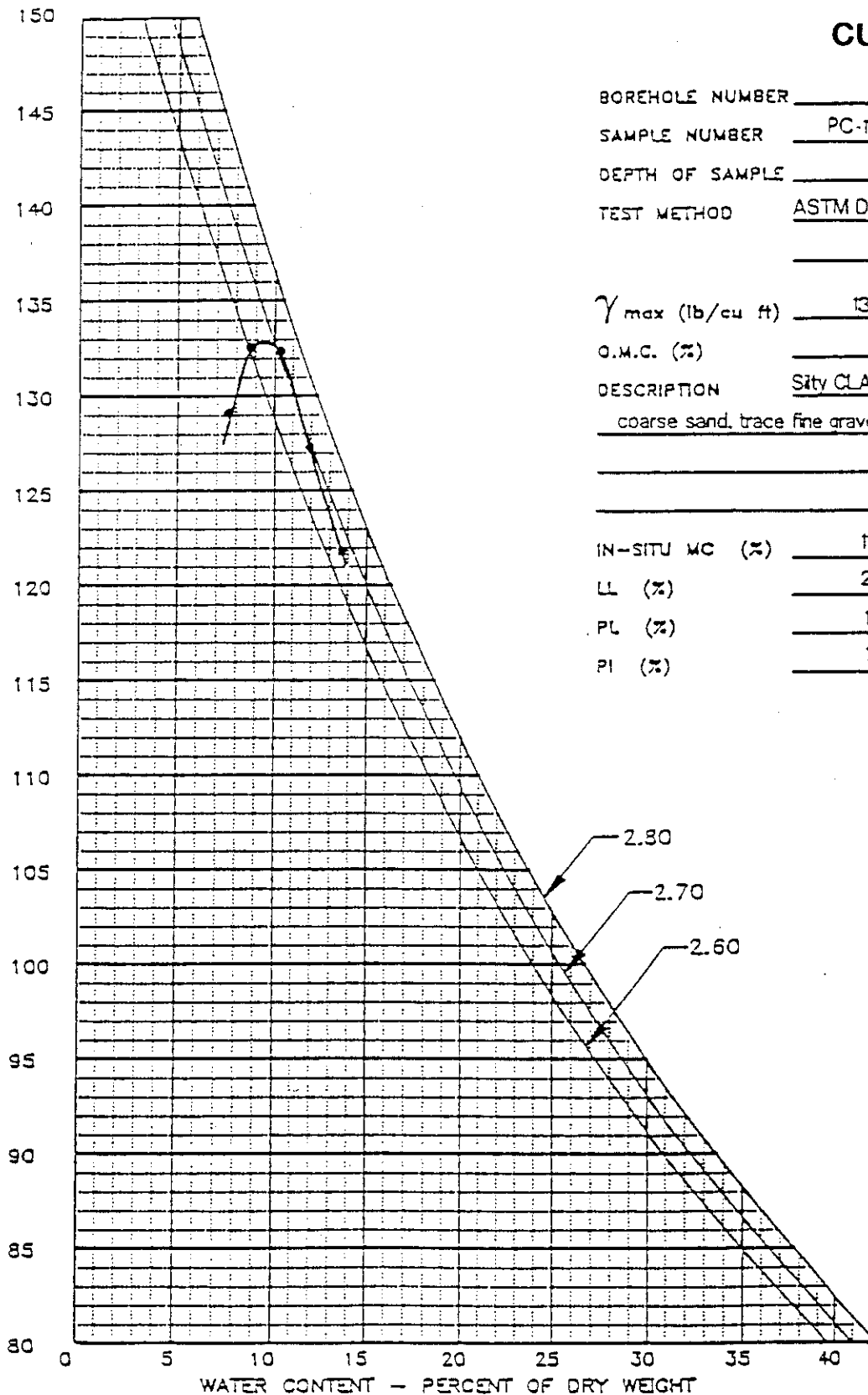
CURVE 25

BOREHOLE NUMBER _____
 SAMPLE NUMBER PC-11
 DEPTH OF SAMPLE _____
 TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 133.0
 O.M.C. (%) 9.5
 DESCRIPTION Silty CLAY with some fine to coarse sand, trace fine gravel (CL)

IN-SITU MC (%) 11.3
 LL (%) 26
 PL (%) 15
 PI (%) 11

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



Denver, Colorado

TITLE

PROCTOR CURVE
PC-11

CLIENT/PROJECT

GCS/927-1203/MI

DRAWN CG

DATE OCT 1992

JOB NO. IC3-2048

CHECKED TT

SCALE

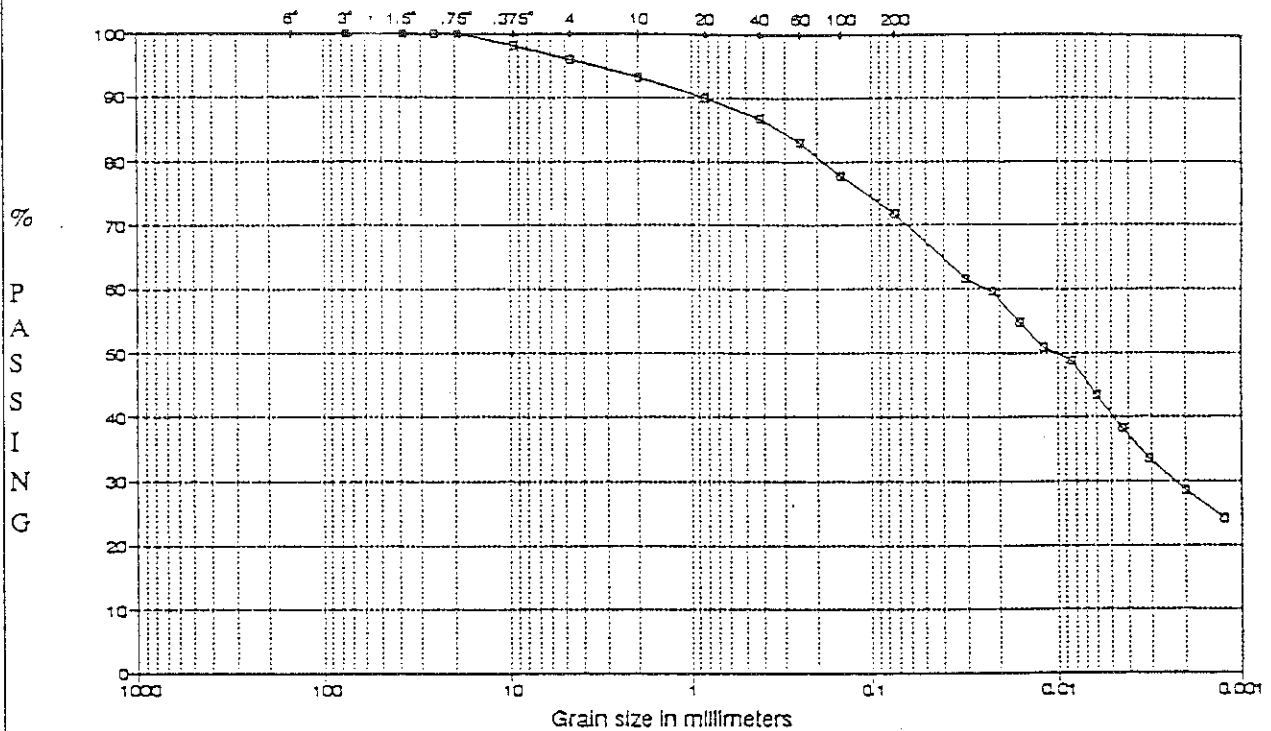
DWG NO./REV. NO.

REVIEWED DR

FILE NO.

FIGURE NO.

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS

COBBLES	Coarse	Fine	Co	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-11 DEPTH	11.3	26	15	11	2.77	Silty CLAY with some fine to coarse sand, trace fine gravel
Sample Type:		Date Tested: SEPT 1992			USCS: CL	

GCS/927-1203/MI
IC3-2048

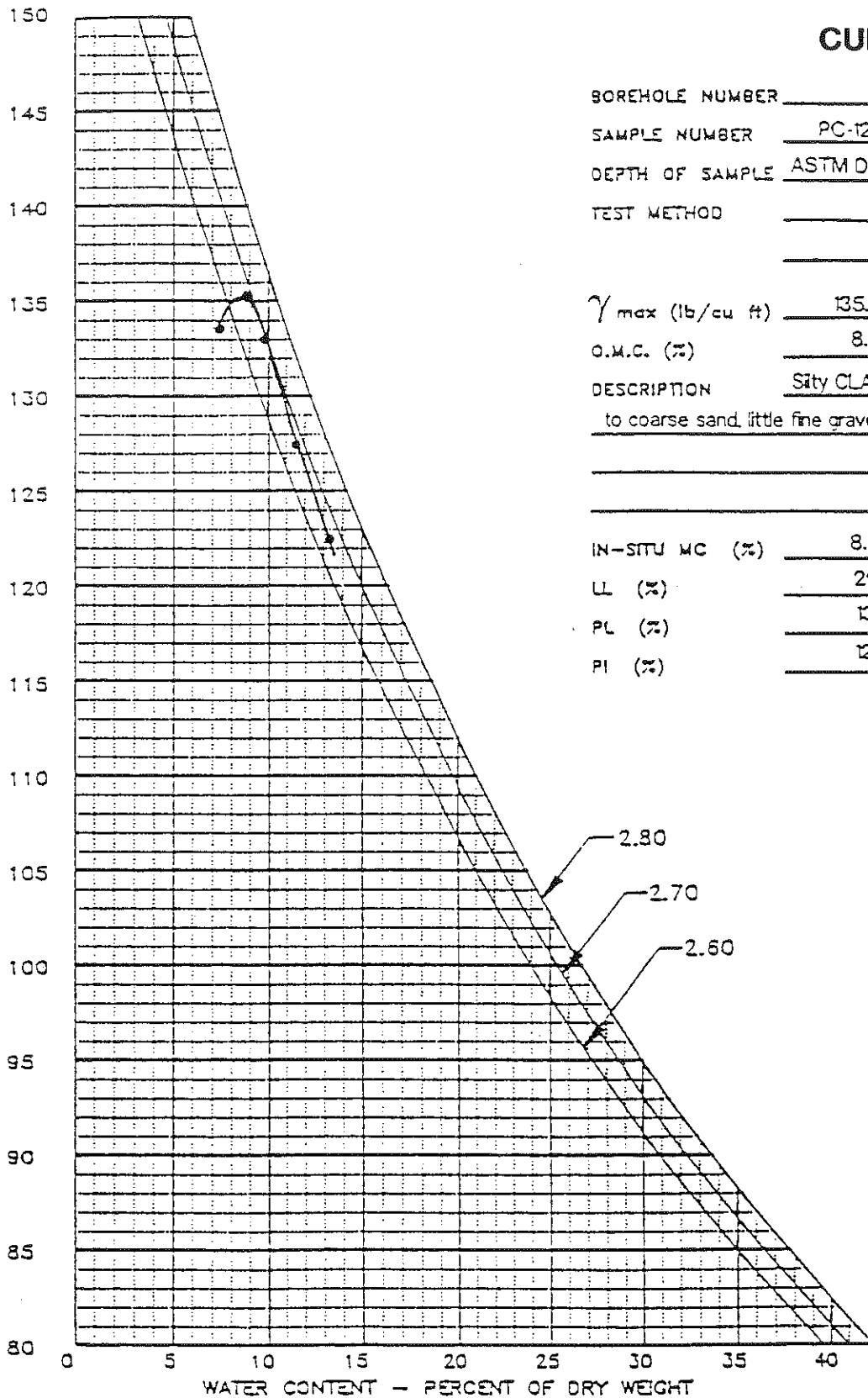
TECH: CG
DATE: 10/07/92
CHECKED: TT
REVIEWED: DR

FILENAME: D4PC11

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

CURVE 26

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



BOREHOLE NUMBER _____
 SAMPLE NUMBER PC-12
 DEPTH OF SAMPLE ASTM D1557 METHOD A
 TEST METHOD _____

 γ_{max} (lb/cu ft) 135.0
 O.M.C. (%) 8.5
 DESCRIPTION Silty CLAY with some fine to coarse sand, little fine gravel (CL)

 IN-SITU MC (%) 8.9
 LL (%) 25
 PL (%) 13
 PI (%) 12



Golder Associates

Denver, Colorado

CLIENT/PROJECT

GCS/927-1203/MI

TITLE

**PROCTOR CURVE
PC-12**

DRAWN CG

DATE OCT 1992

JOB NO. IC3-2048

CHECKED TT

SCALE

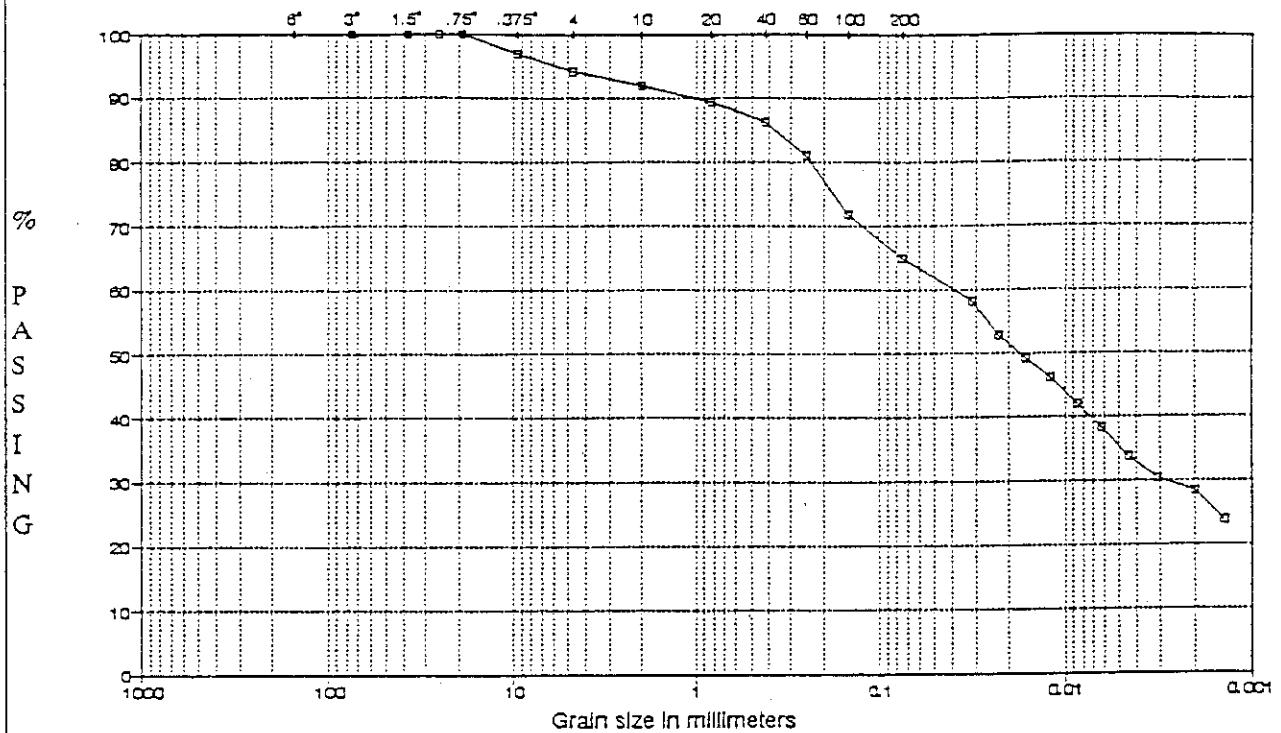
DWG NO./REV. NO.

REVIEWED DR

FILE NO.

FIGURE NO.

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS

COBBLES	Coarse	Fine	Coar	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-12 DEPTH	8.9	25	13	12	2.70	Silty CLAY and fine to coarse SAND, trace fine gravel

Sample Type:

Date Tested: SEPT 1992

USCS: CL

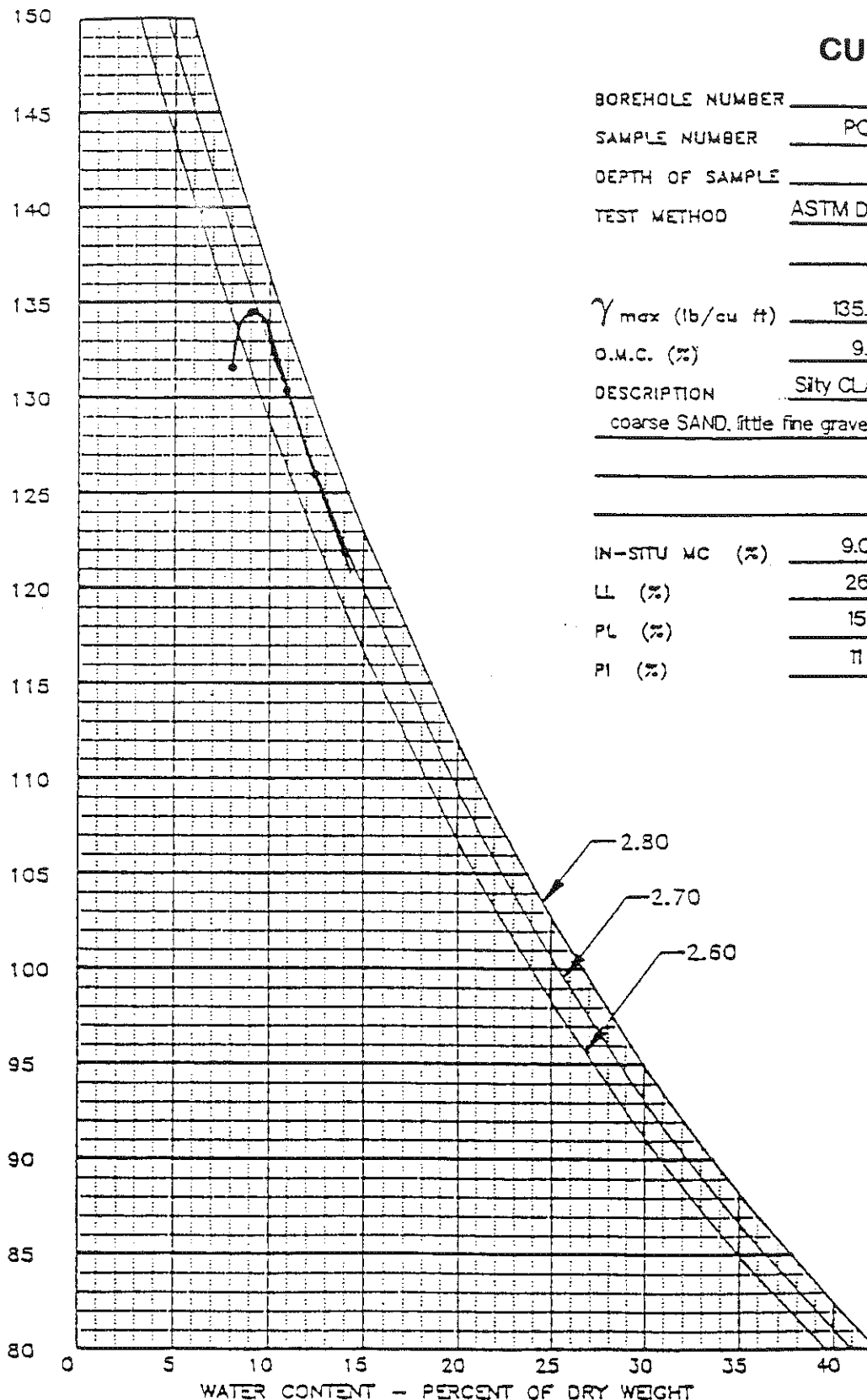
TECH: CG
DATE: 10/07/92
CHECKED: TT
REVIEWED: DR

GCS/927-1203/MI
IC3-2048

FILENAME: D4MPC12

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



CURVE 27

BOREHOLE NUMBER _____

SAMPLE NUMBER PC-13

DEPTH OF SAMPLE _____

TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 135.0

O.M.C. (%) 9.0

DESCRIPTION Silty CLAY and fine to coarse SAND, little fine gravel (CL)

IN-SITU MC (%) 9.0

LL (%) 26

PL (%) 15

PI (%) 11



Denver, Colorado

TITLE

PROCTOR CURVE
PC-13

CLIENT/PROJECT

GCS/927-1203/MI

DRAWN CG

DATE OCT 1992

JOB NO. IC3-2043

CHECKED TT

SCALE

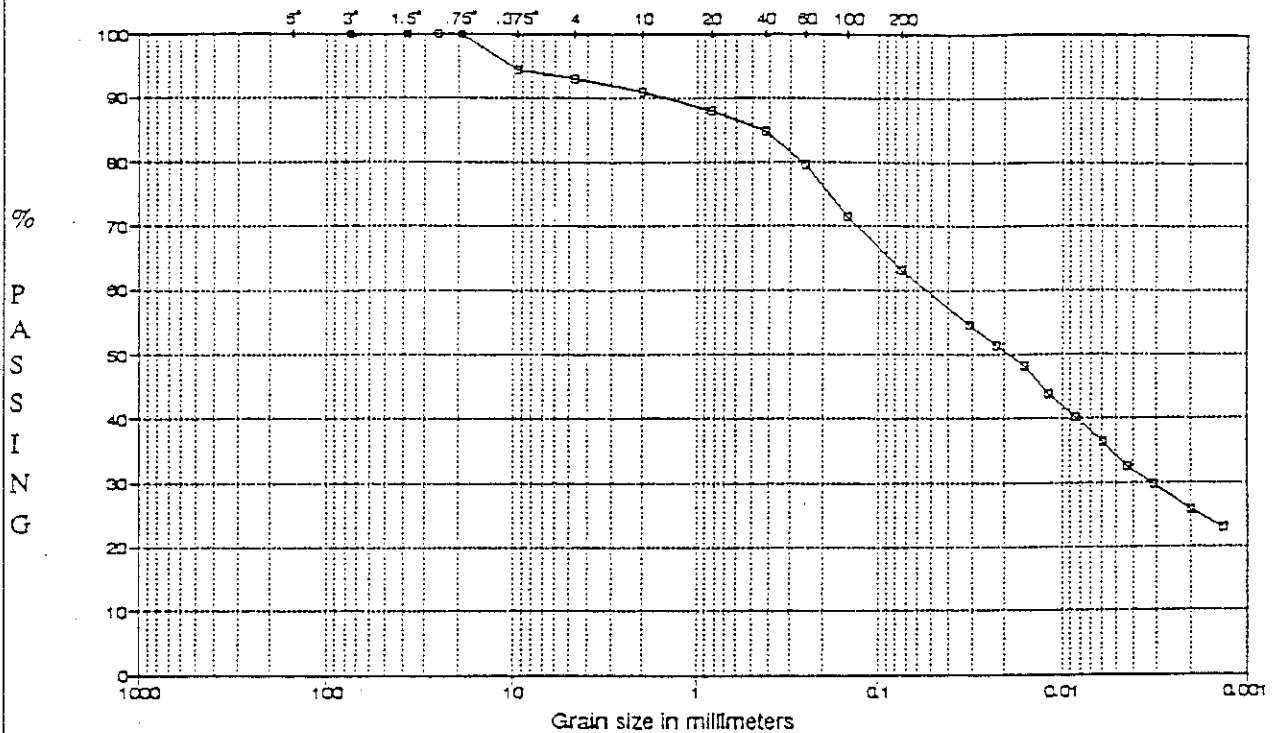
DWG NO./REV. NO.

REVIEWED DR

FILE NO.

FIGURE NO.

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS

COBBLES	Coarse	Fine	Coar	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-13 DEPTH	9.0	26	15	11	2.81	Silty CLAY and fine to coarse SAND, little fine gravel
Sample Type:		Date Tested: SEPT 1992			USCS: CL	

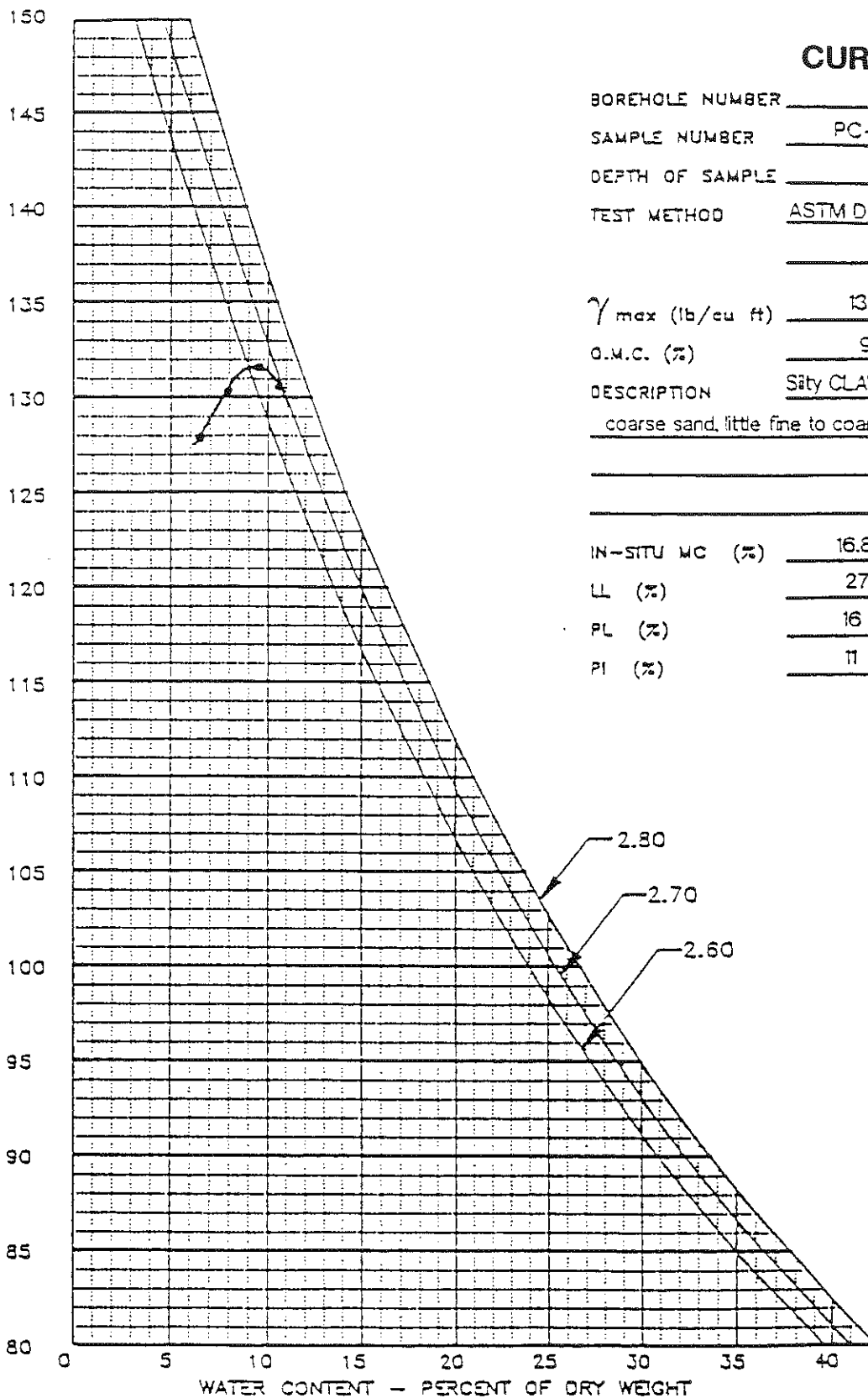
TECH: CG
DATE: 10/07/92
CHECKED: TT
REVIEWED: DR

GCS/927-1203/MI
IC3-2048

FILENAME 344PC13

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



CURVE 28

BOREHOLE NUMBER _____
 SAMPLE NUMBER PC-14
 DEPTH OF SAMPLE _____
 TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 131.5
 O.M.C. (%) 9.0
 DESCRIPTION Silty CLAY with some fine to coarse sand, little fine to coarse gravel (CL)

IN-SITU MC (%) 16.8
 LL (%) 27
 PL (%) 16
 PI (%) 11



Golder Associates

Denver, Colorado

TITLE

**PROCTOR CURVE
PC-14**

CLIENT/PROJECT

GCS/927-1203/MI

DRAWN

DATE

LOB NO.

CHECKED

SCALE

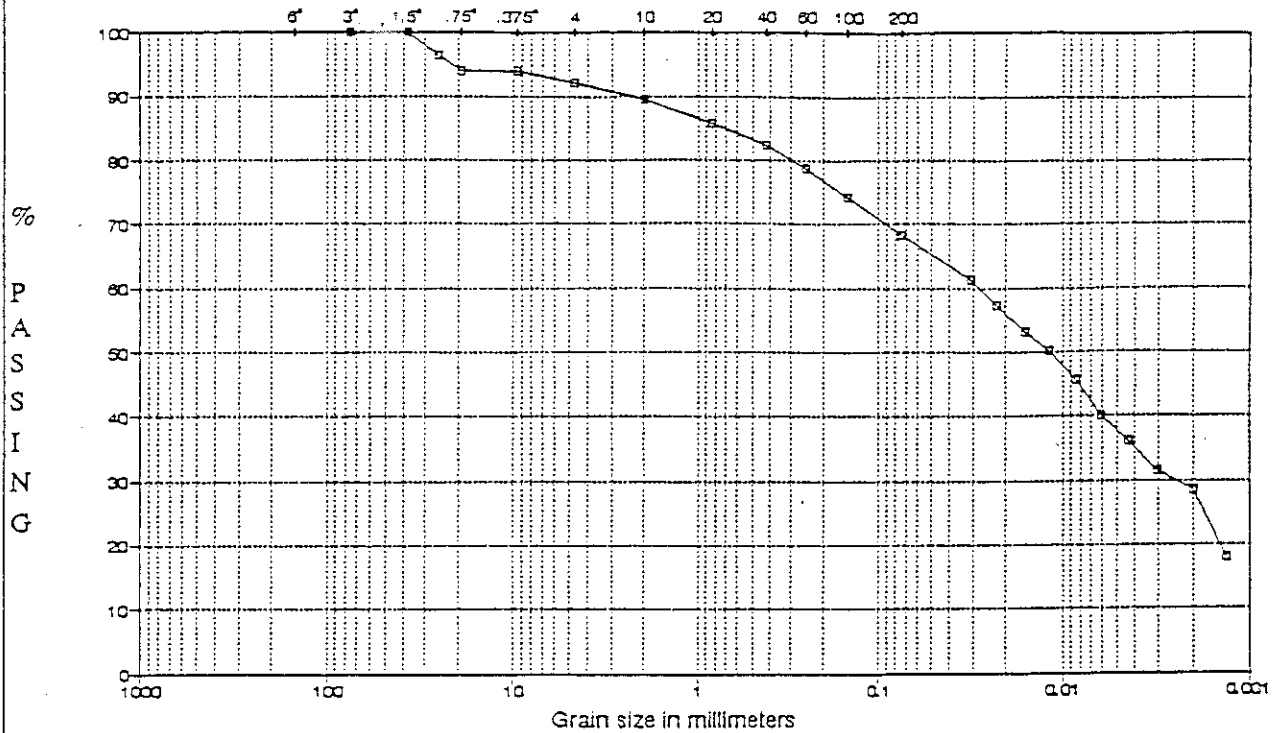
DWG NO./REV. NO.

REVIEWED

FILE NO.

FIGURE NO.

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS

COBBLES	Coarse	Fine	Cor	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-14 DEPTH	16.8	27	16	11	2.77	Silty CLAY with some fine to coarse sand, little fine to coarse gravel

Sample Type:

Date Tested: SEPT 1992

USCS: CL

TECH: CG

DATE: 10/07/92

CHECKED: TT

REVIEWED: DR

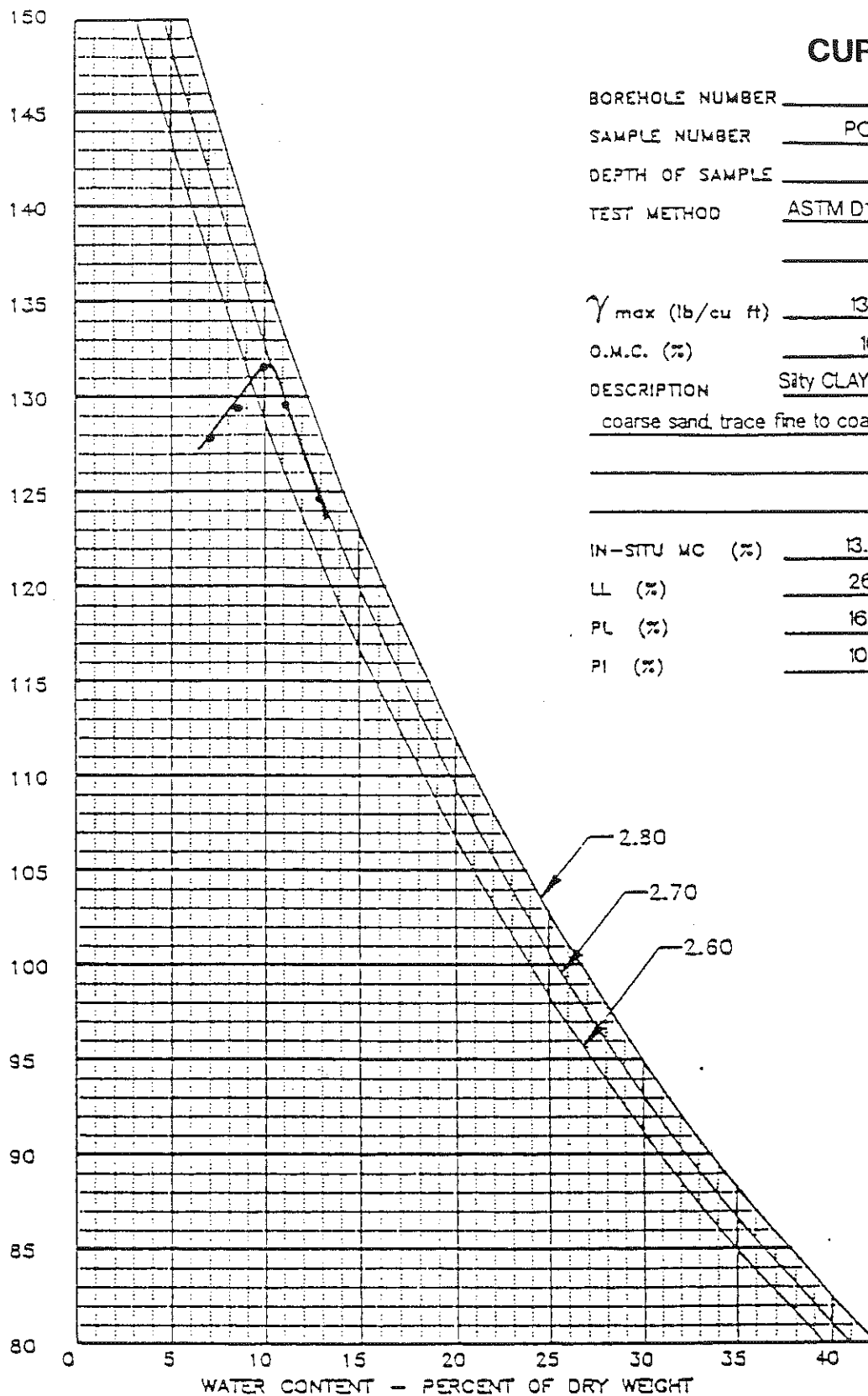
GCS/927-1203/MI

IC3-2048

FILENAME: D4PC14

**GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO**

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



CURVE 29

BOREHOLE NUMBER _____
 SAMPLE NUMBER PC-15
 DEPTH OF SAMPLE _____
 TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 132.0
 O.M.C. (%) 10.0
 DESCRIPTION Silty CLAY with some fine to coarse sand, trace fine to coarse gravel (CL)

IN-SITU MC (%) 13.1
 LL (%) 26
 PL (%) 16
 PI (%) 10



Golder Associates

Denver, Colorado

CLIENT/PROJECT

GCS/927-1203/MI

TITLE

**PROCTOR CURVE
PC-15**

DRAWN CG

DATE OCT 1992

JOB NO. IC3-2048

CHECKED TT

SCALE

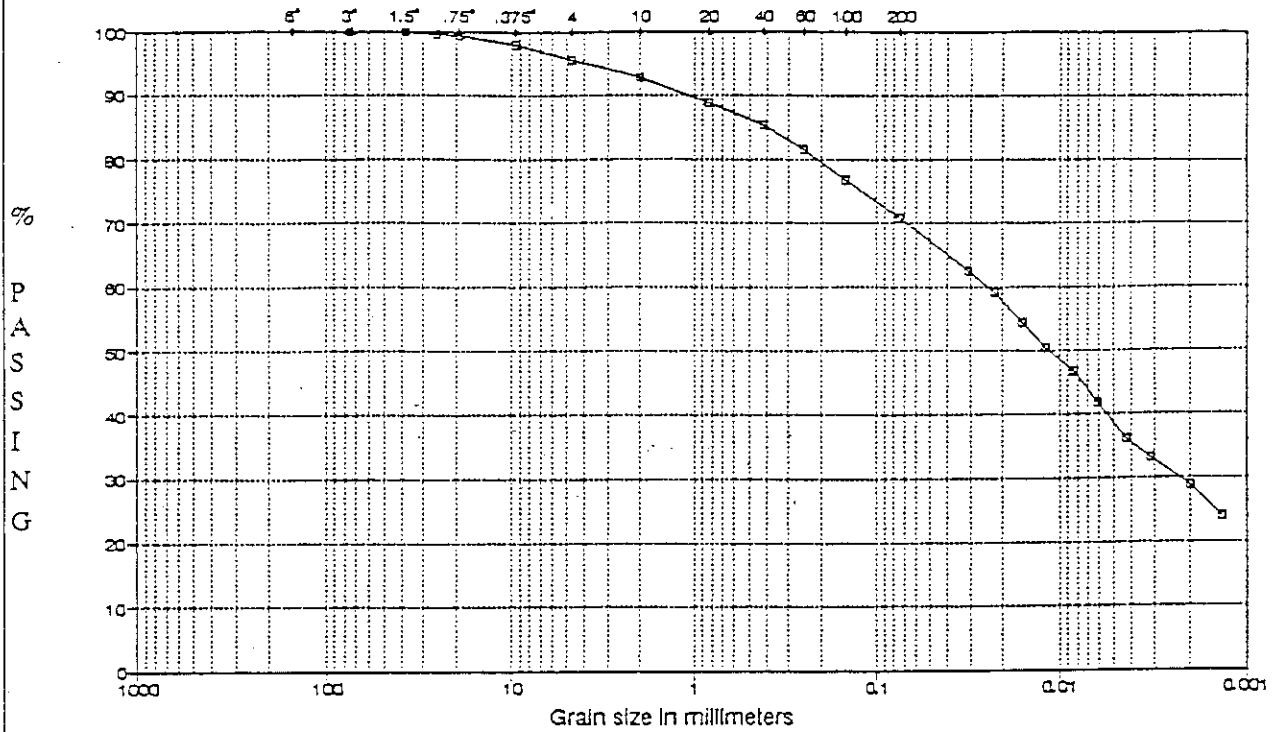
DWG NO./REV. NO.

REVIEWED DR

FILE NO.

FIGURE NO.

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS

COBBLES	Coarse	Fine	Car	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-15 DEPTH	13.1	26	16	10	2.74	Silty CLAY with some fine to coarse sand, trace fine gravel
Sample Type:		Date Tested: OCT 1992				USCS: CL

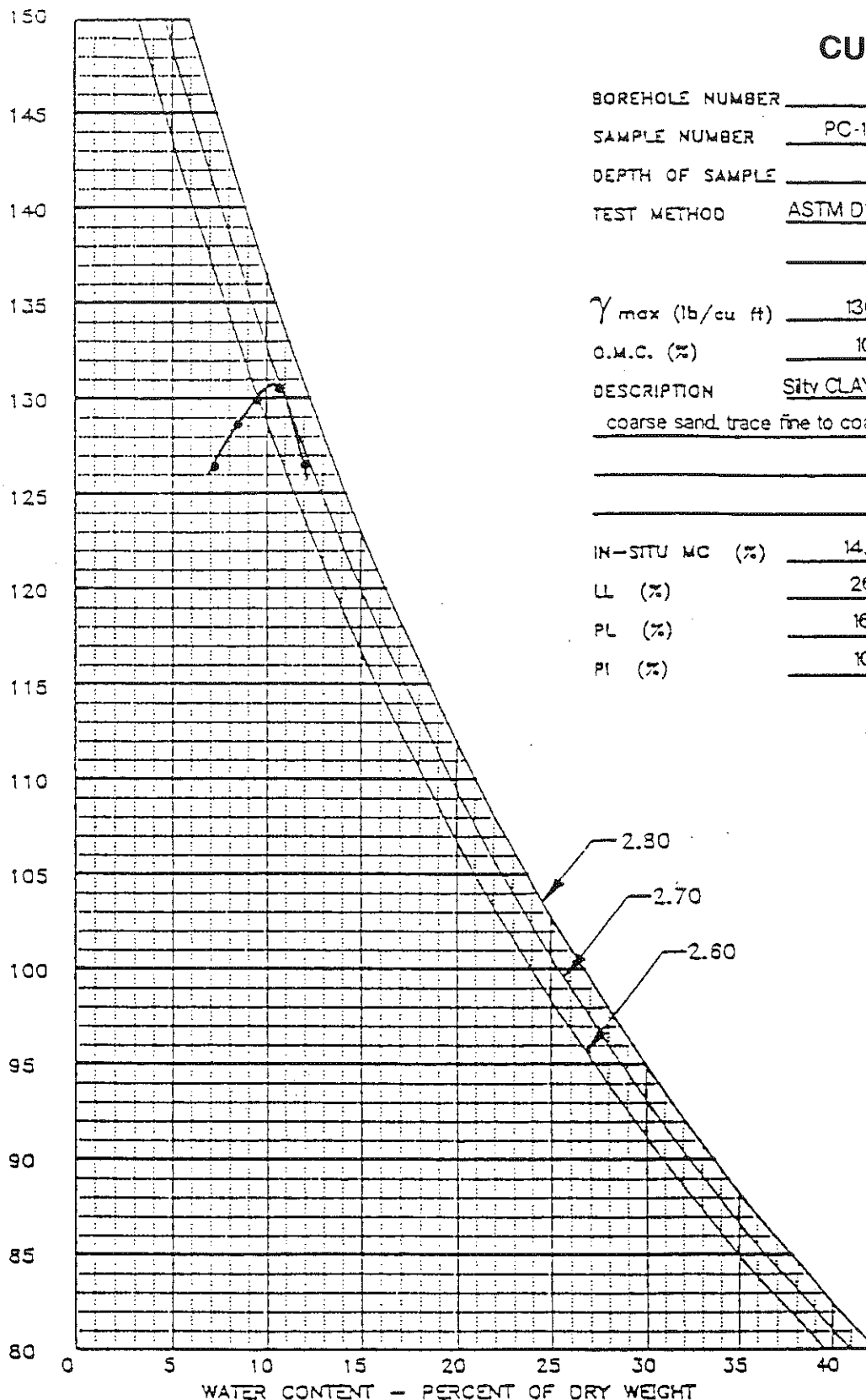
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 DATE: 10/07/92
 CHECKED: TT
 REVIEWED:

GCS/927-1203/MI
 IC3-2048

FILENAME: 2048.CS

GOLDER ASSOCIATES INC.
 LAKEWOOD, COLORADO

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



CURVE 30

BOREHOLE NUMBER _____
SAMPLE NUMBER PC-16
DEPTH OF SAMPLE _____
TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 130.5
O.M.C. (%) 10.5
DESCRIPTION Silty CLAY with some fine to coarse sand, trace fine to coarse gravel (CL)

IN-SITU MC (%) 14.1
LL (%) 26
PL (%) 16
PI (%) 10



Golder Associates

Denver, Colorado

TITLE

**PROCTOR CURVE
PC-16**

CLIENT/PROJECT

GCS/927-1203/MI

DRAWN CG

DATE OCT 1992

JOB NO. IC3-2048

CHECKED TT

SCALE

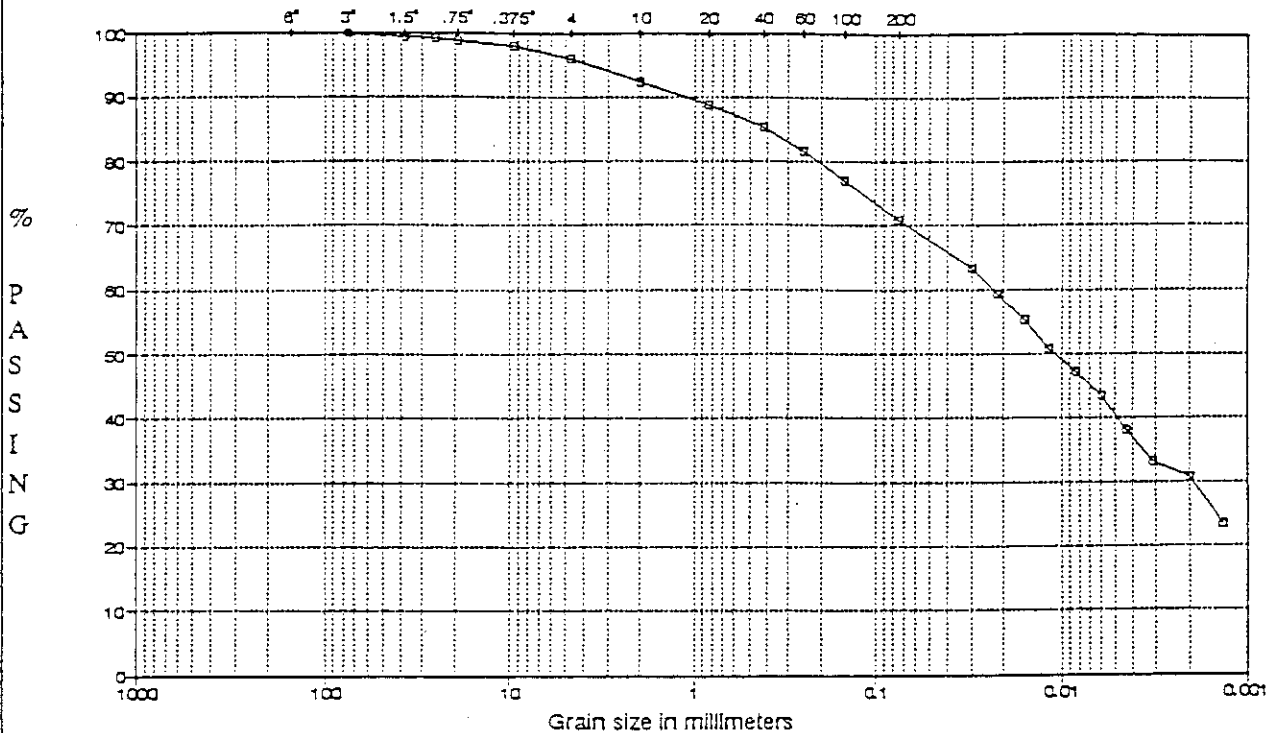
DWG NO./REV. NO.

REVIEWED DR

FILE NO.

FIGURE NO.

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS

COBBLES	Coarse	Fine	Cor	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-16 DEPTH	14.1	26	16	10	2.72	Silty CLAY with some fine to coarse sand, trace fine to coarse gravel

Sample Type: Date Tested: OCT 1992 USCS: CL

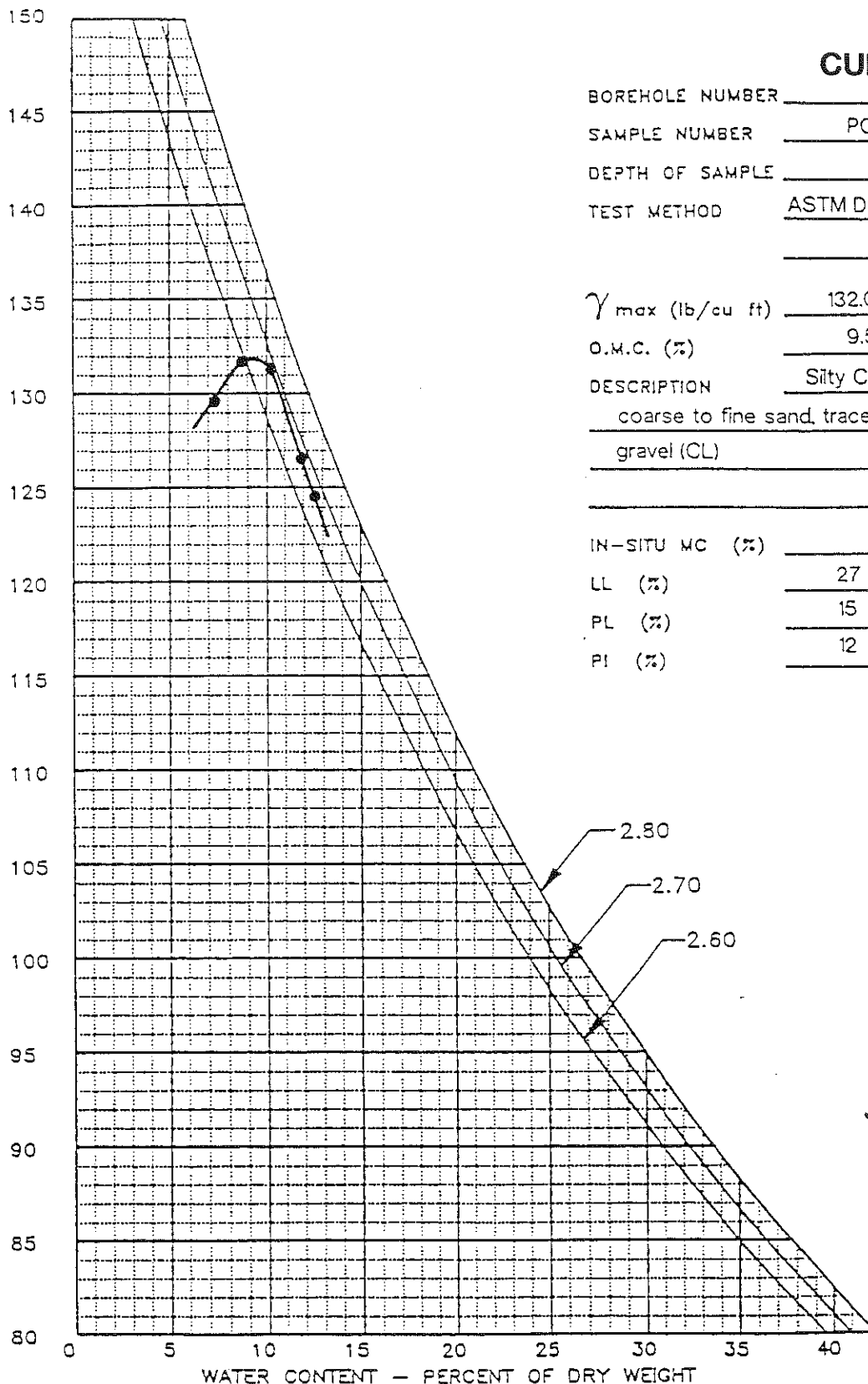
TECH: KRB
DATE: 10/07/92
CHECKED: TT
REVIEWED: DR

GCS/927-1203/MI
IC3-2048

FILENAME: 344PC16

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



CURVE 31

BOREHOLE NUMBER _____
SAMPLE NUMBER PC-21
DEPTH OF SAMPLE _____
TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 132.0
O.M.C. (%) 9.5
DESCRIPTION Silty CLAY with some
coarse to fine sand, trace coarse to fine
gravel (CL)

IN-SITU MC (%) _____
LL (%) 27
PL (%) 15
PI (%) 12



Golder Associates

Denver, Colorado

TITLE

**PROCTOR CURVE
PC-21**

CLIENT/PROJECT

GCS/927-1203/MI

DRAWN CG

DATE NOV 1992

JOB NO. IC3-2048

CHECKED KR

SCALE AS SHOWN

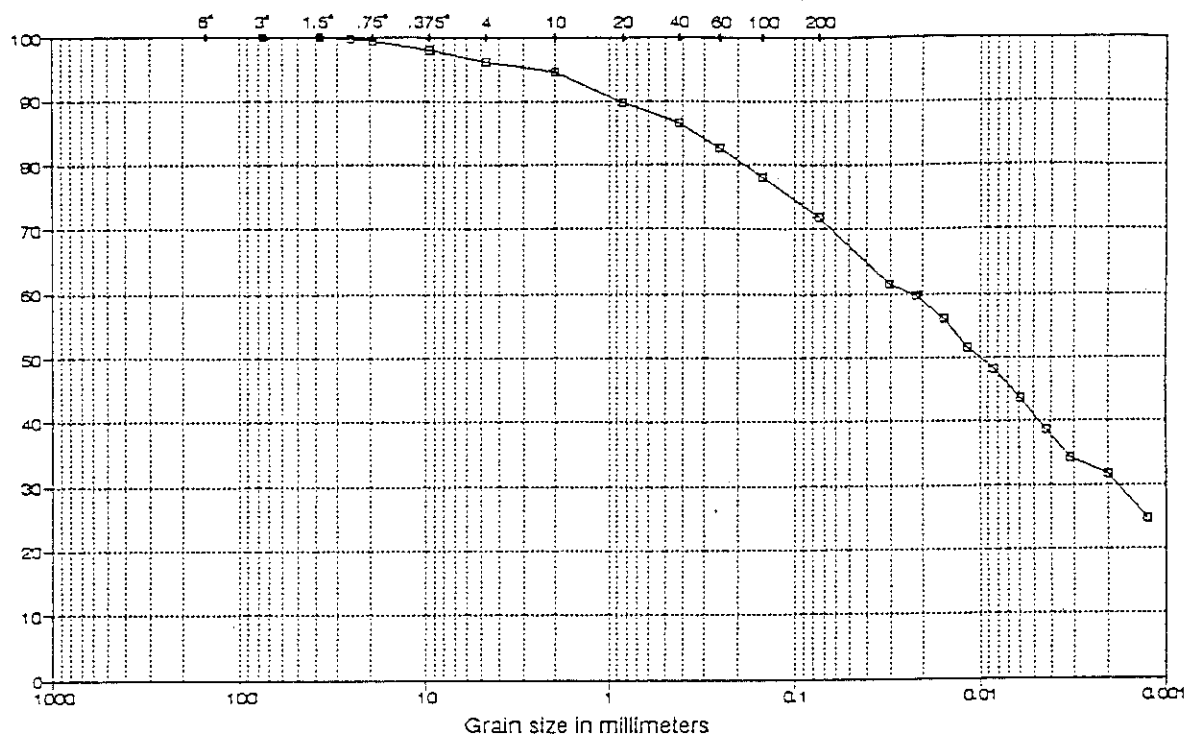
DWG NO./REV. NO.

REVIEWED DR

FILE NO. WATER.DWG

FIGURE NO.

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361	362	363
364	365	366



USCS	COBBLES	Coarse	Fine	Coar	Med	Fine	FINES (Silt and Clay)
		GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-21 DEPTH		27	15	12	2.72	Silty CLAY with some coarse to fine sand, trace coarse to fine gravel
Sample Type:	Date Tested: OCT 1992				USCS: CL	

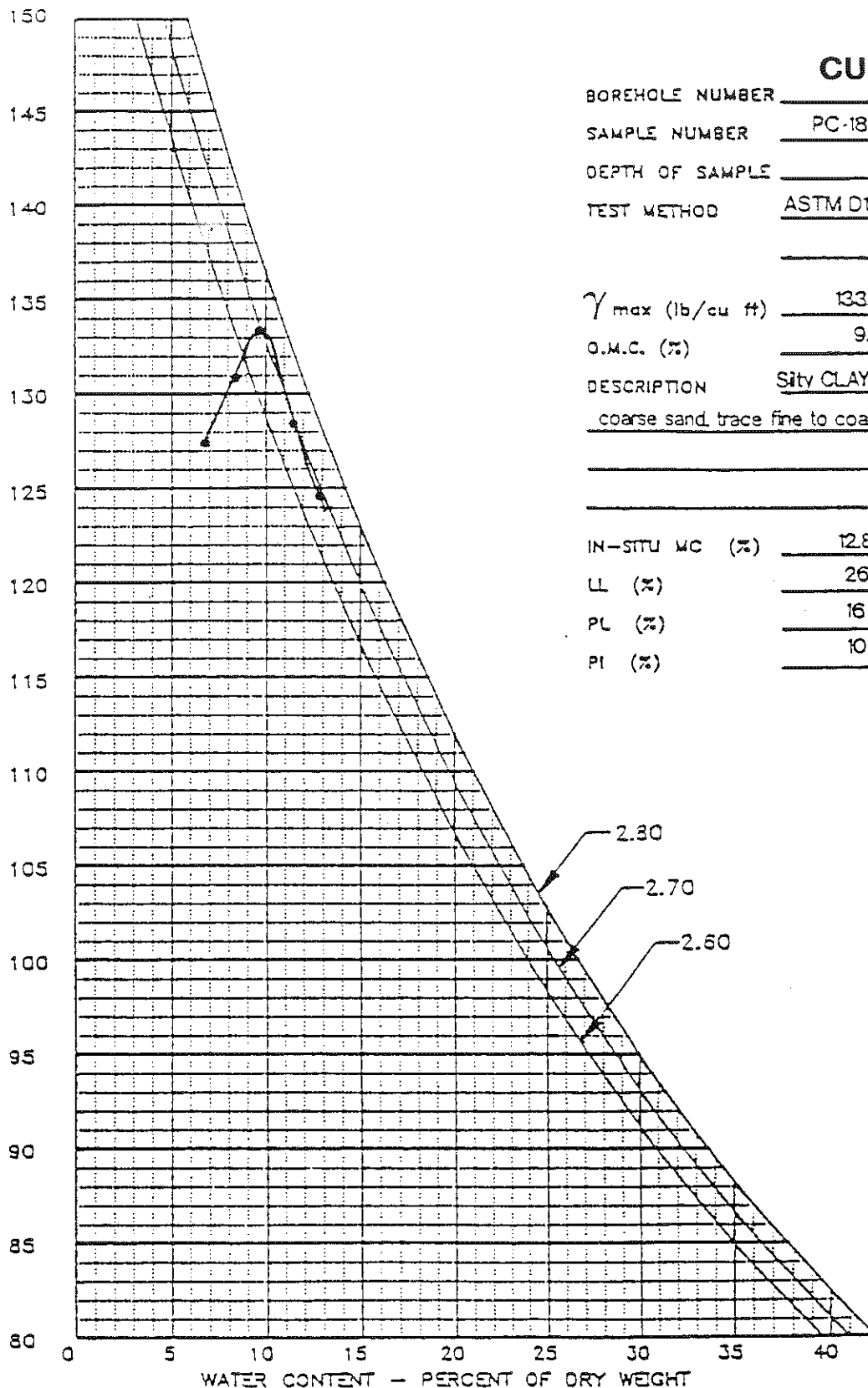
GCS/927-1203/MI
IC3-2048

TECH: MK
DATE: 11/09/92
CHECKED: KR
REVIEWED: DR

FILENAME 3048P01

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



CURVE 32

BOREHOLE NUMBER _____
 SAMPLE NUMBER PC-18
 DEPTH OF SAMPLE _____
 TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 133.5
 O.M.C. (%) 9.5
 DESCRIPTION Silty CLAY with some fine to coarse sand, trace fine to coarse gravel (CL)

IN-SITU MC (%) 12.8
 LL (%) 26
 PL (%) 16
 PI (%) 10



**Golder
Associates**

Denver, Colorado

CLIENT/PROJECT

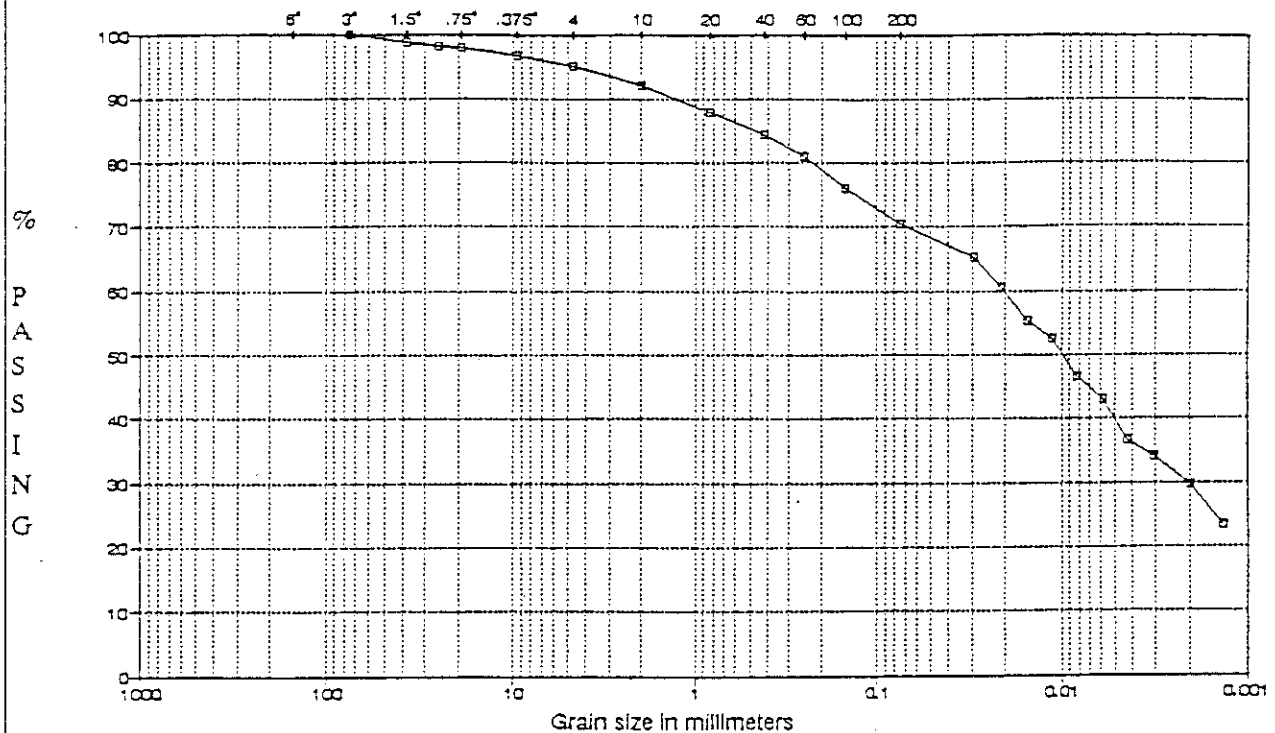
GCS/927-1203/MI

TITLE

**PROCTOR CURVE
PC-18**

DRAWN	CG	DATE	OCT 1992	JOB NO.	IC3-2048
CHECKED	TT	SCALE		DWG NO./REV. NO.	
REVIEWED	DR	FILE NO.		FIGURE NO.	

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS

COBBLES	Coarse	Fine	Gr	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-18 DEPTH	12.8	26	16	10	2.74	Silty CLAY with some fine to coarse sand, trace fine to coarse gravel

Sample Type:

Date Tested: OCT 1992

USCS: CL

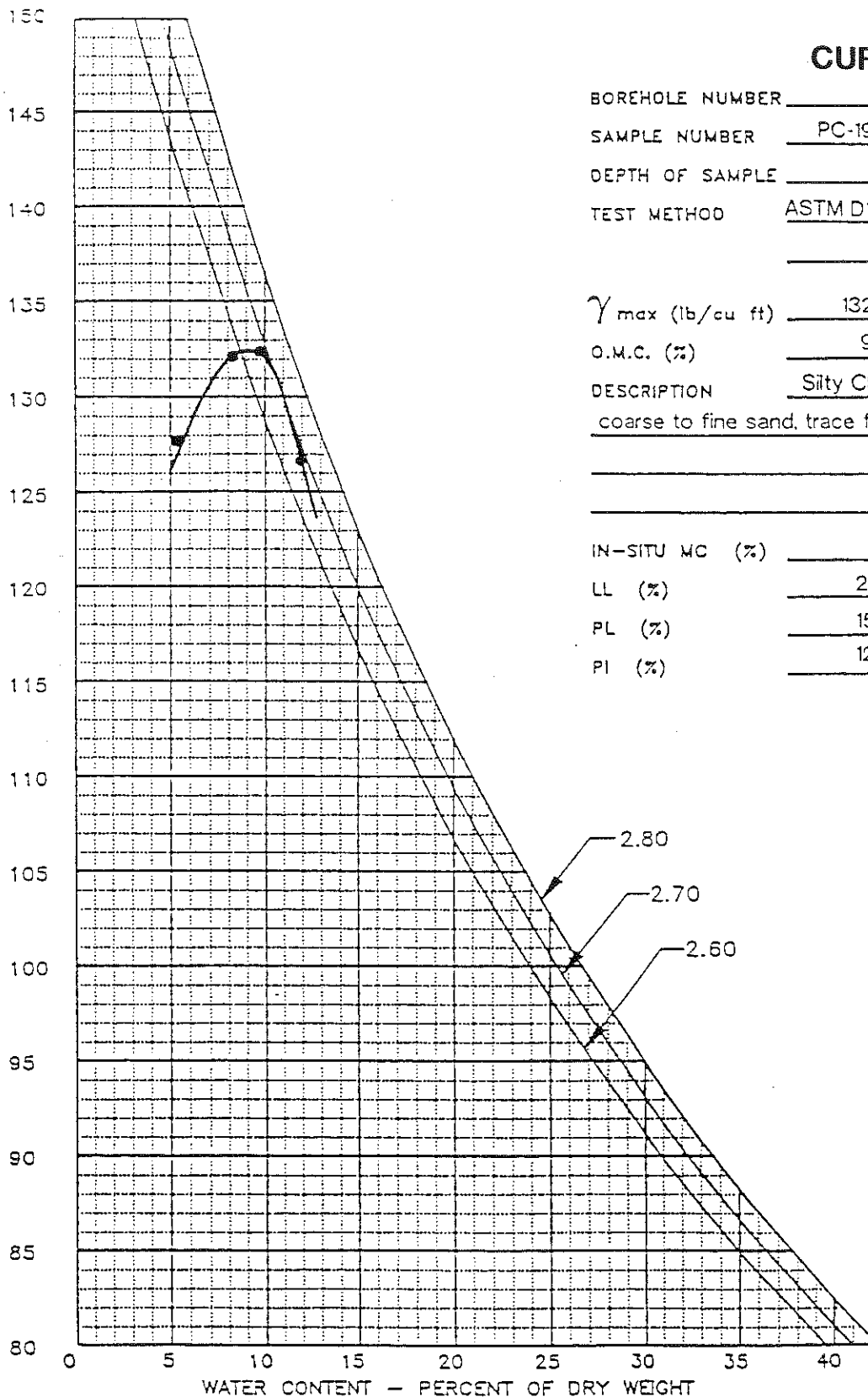
TECH: KRB
DATE: 10/07/92
CHECKED: TT
REVIEWED: DR

GCS/927-1203/MI
IC3-2048

FILENAME: D4PCL

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



CURVE 33

BOREHOLE NUMBER _____
SAMPLE NUMBER PC-19
DEPTH OF SAMPLE _____
TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 132.5
O.M.C. (%) 9.0
DESCRIPTION Silty CLAY with some
coarse to fine sand, trace fine gravel (CL)

IN-SITU MC (%) _____
LL (%) 27
PL (%) 15
PI (%) 12



Golder Associates

Denver, Colorado

TITLE

**PROCTOR CURVE
PC-19**

CLIENT/PROJECT

GCS/927-1203/MI

DRAWN MS

DATE NOV 1992

JOB NO. IC3-2048

CHECKED KR

SCALE AS SHOWN

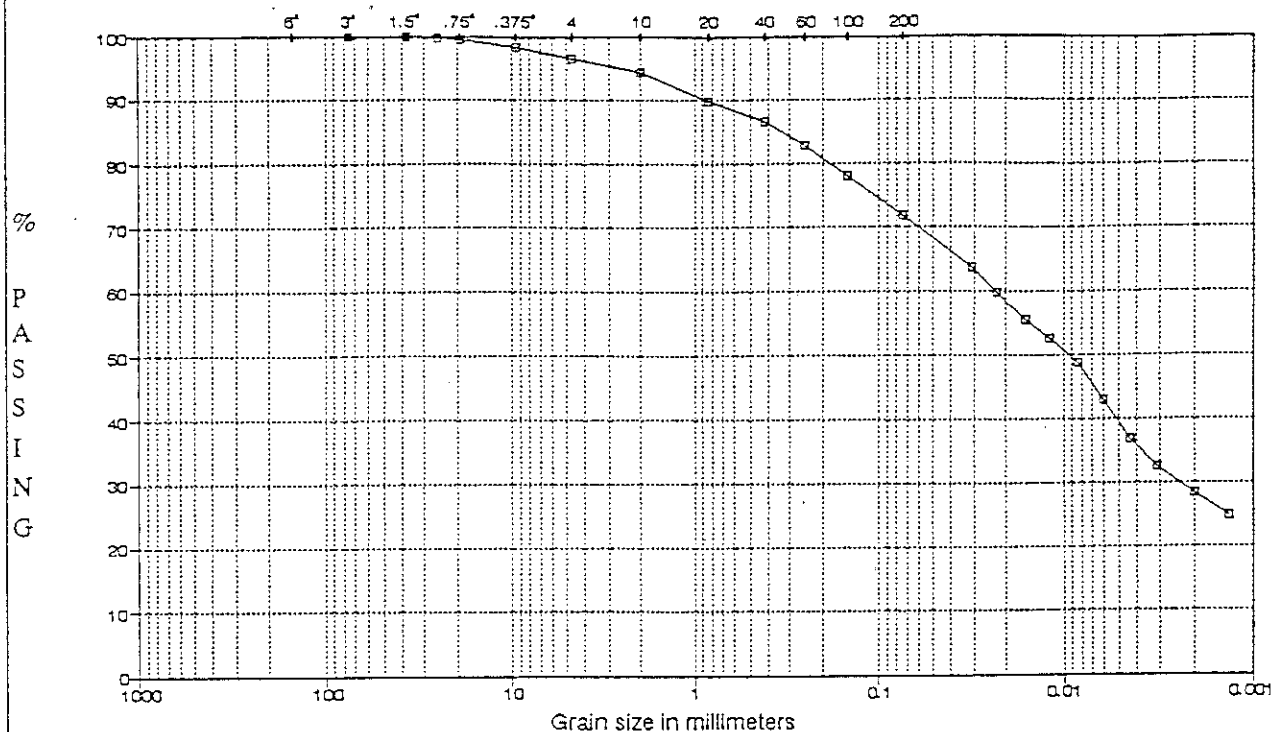
DWG NO./REV. NO.

REVIEWED DR

FILE NO. WATER.DWG

FIGURE NO.

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS

COBBLES	Coarse	Fine	Co	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-19 DEPTH		27	15	12	2.72	Silty CLAY with some coarse to fine sand, trace fine gravel
Sample Type:		Date Tested: OCT 1992				USCS: CL

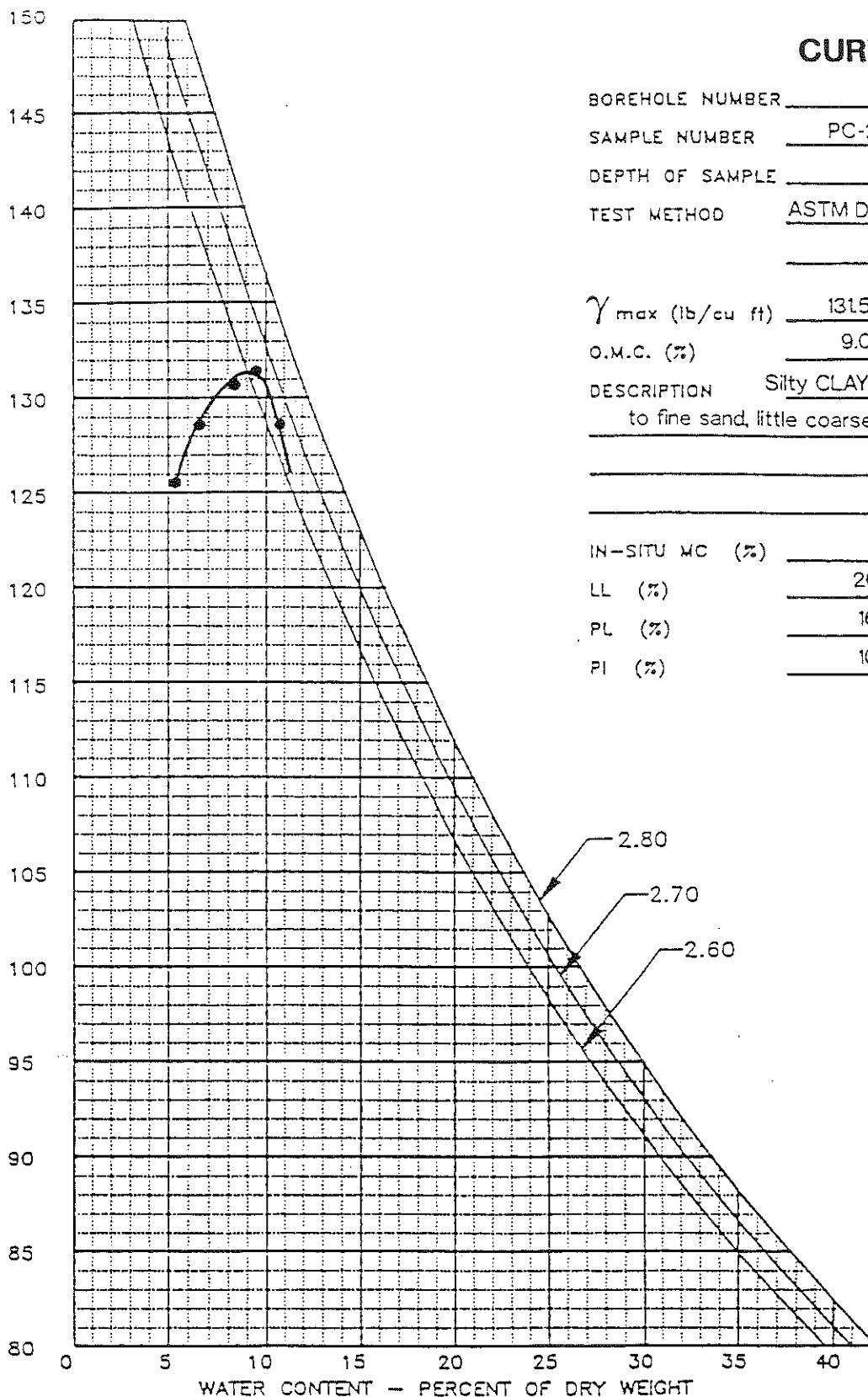
TECH: MK
DATE: 11/10/92
CHECKED: KR
REVIEWED: DR

GCS/927-1203/MI
IC3-2048

FILENAME: 048PC19

**GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO**

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



CURVE 34

BOREHOLE NUMBER _____
 SAMPLE NUMBER PC-20
 DEPTH OF SAMPLE _____
 TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 131.5
 O.M.C. (%) 9.0
 DESCRIPTION Silty CLAY with some coarse to fine sand, little coarse to fine gravel (CL)

IN-SITU MC (%) _____
 LL (%) 26
 PL (%) 16
 PI (%) 10



Denver, Colorado

TITLE

PROCTOR CURVE
PC-20

CLIENT/PROJECT

GCS/927-1203/MI

DRAWN MS

DATE NOV 1992

JOB NO. IC3-2048

CHECKED KR

SCALE AS SHOWN

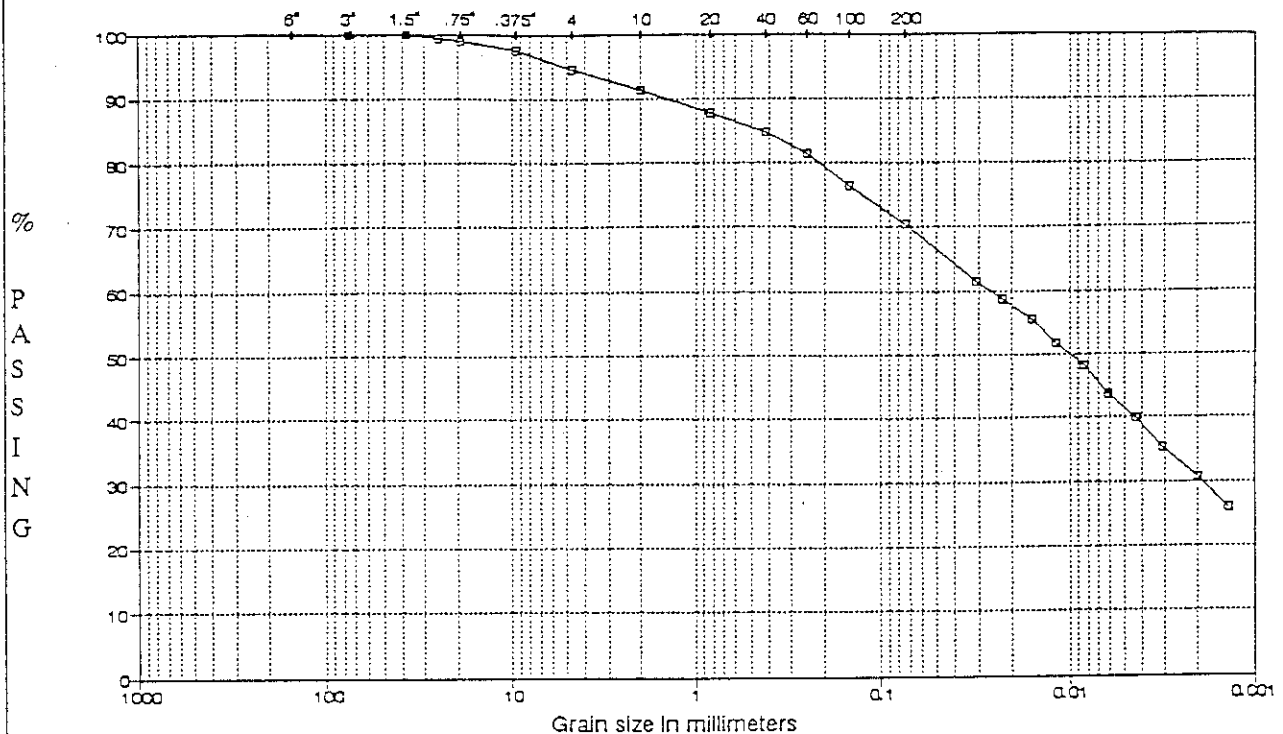
DWG NO./REV. NO.

REVIEWED DR

FILE NO. WATER.DWG

FIGURE NO.

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS

COBBLES	Coarse	Fine	Cor	Med	Fine	FINES (Silt and Clay)
	GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-20 DEPTH		26	16	10	2.71	Silty CLAY with some coarse to fine sand, little coarse to fine gravel
Sample Type:		Date Tested: OCT 1992				USCS: CL

GCS/927-1203/MI
IC3-2048

TECH: MK
DATE: 11/09/92
CHECKED: KR
REVIEWED: DR

FILENAME: 2048PC20

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

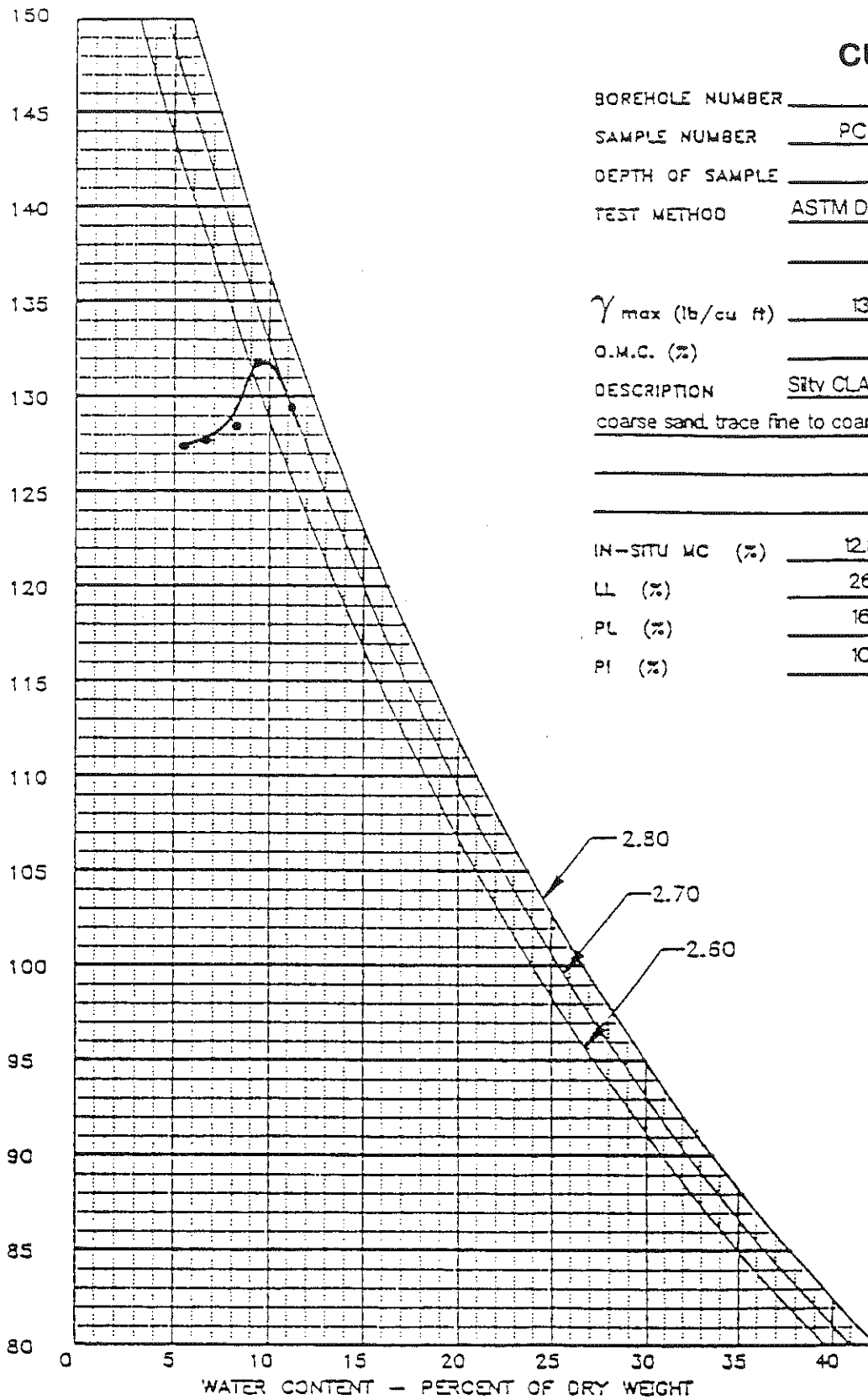
CURVE 35

BOREHOLE NUMBER _____
 SAMPLE NUMBER PC-17
 DEPTH OF SAMPLE _____
 TEST METHOD ASTM D1557 METHOD A

γ_{max} (lb/cu ft) 132.0
 O.M.C. (%) 9.5
 DESCRIPTION Silty CLAY with some fine to coarse sand, trace fine to coarse gravel (CL)

IN-SITU MC (%) 12.8
 LL (%) 26
 PL (%) 16
 PI (%) 10

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



Golder Associates

Denver, Colorado

TITLE

**PROCTOR CURVE
PC-17**

CLIENT/PROJECT

GCS/927-1203/MI

DRAWN CG

DATE OCT 1992

JOB NO. IC3-2048

CHECKED TT

SCALE

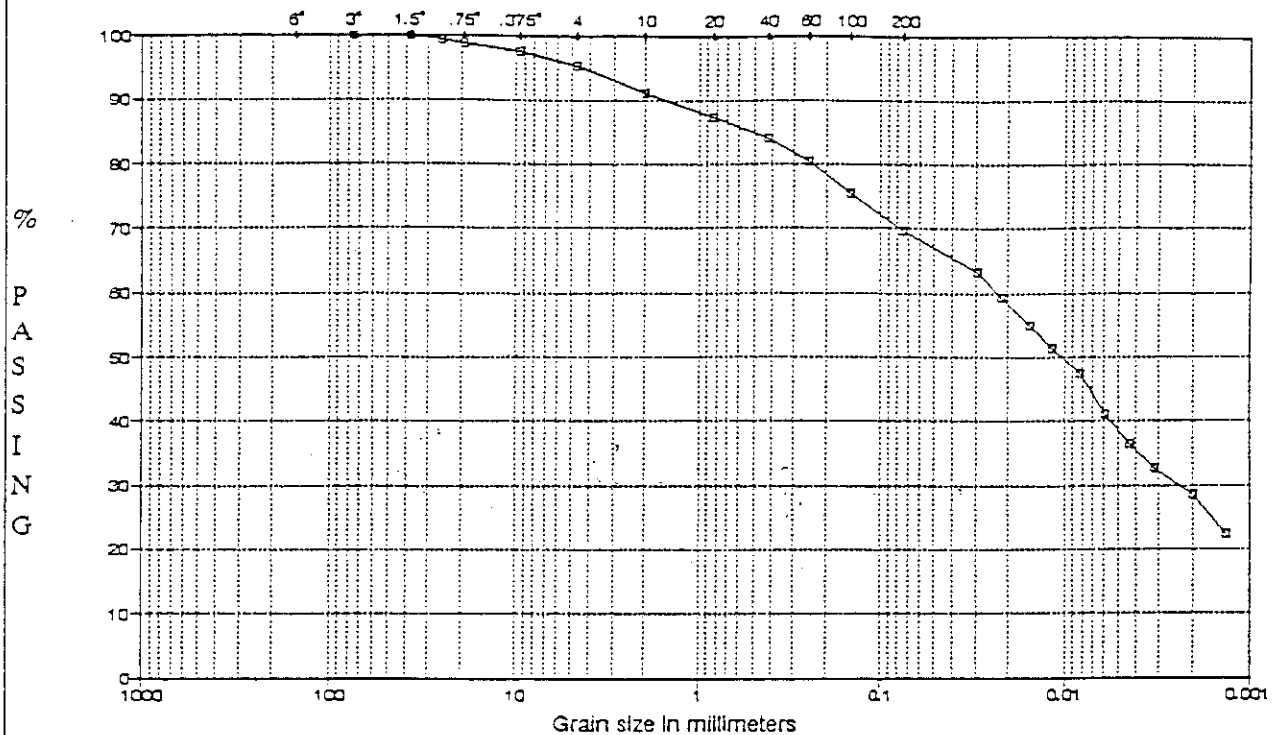
DWG NO./REV. NO.

REVIEWED DR

FILE NO.

FIGURE NO.

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS

	Coarse	Fine	Coar	Med	Fine	
COBBLES	GRAVEL		SAND			FINES (Silt and Clay)

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-17 DEPTH	12.8	26	16	10	2.69	Silty CLAY with some fine to coarse sand, trace fine to coarse gravel

Sample Type:

Date Tested: OCT 1992

USCS: CL

TECH: KRB
DATE: 10/07/92
CHECKED: TT
REVIEWED: DR

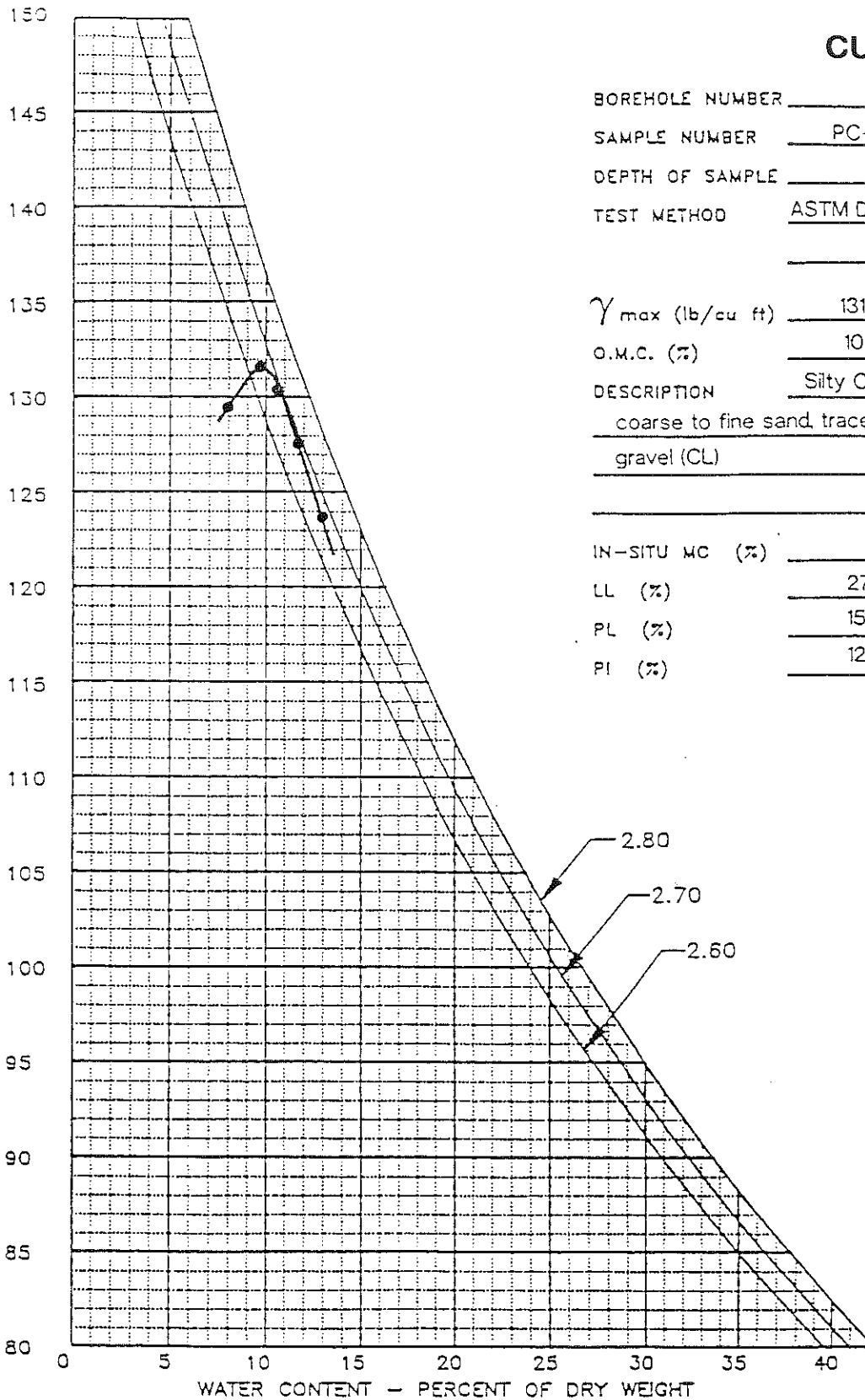
GCS/927-1203/MI
IC3-2048

FILENAME: 04PC17

**GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO**

CURVE 36

DRY UNIT WEIGHT - POUNDS PER CUBIC FOOT



BOREHOLE NUMBER _____
 SAMPLE NUMBER PC-22
 DEPTH OF SAMPLE _____
 TEST METHOD ASTM D1557 METHOD A

 γ_{max} (lb/cu ft) 131.5
 O.M.C. (%) 10.0
 DESCRIPTION Silty CLAY with some
coarse to fine sand, trace coarse to fine
gravel (CL)

 IN-SITU MC (%) _____
 LL (%) 27
 PL (%) 15
 PI (%) 12



**Golder
Associates**

Denver, Colorado

TITLE

**PROCTOR CURVE
PC-22**

CLIENT/PROJECT

GCS/927-1203/MI

DRAWN

CG

DATE

NOV 1992

JOB NO.

IC3-2048

CHECKED

KR

SCALE

AS SHOWN

DWG NO./REV. NO.

REVIEWED

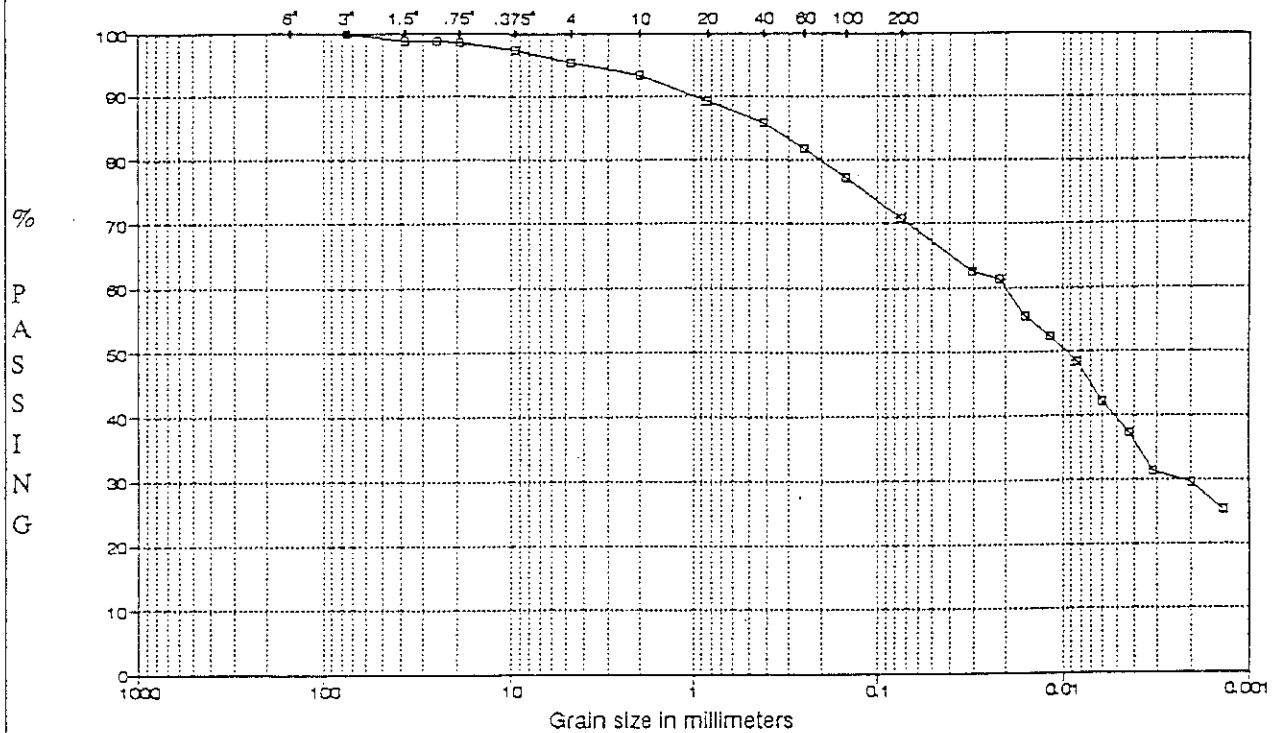
DR

FILE NO.

WATER.DWG

FIGURE NO.

**PARTICLE SIZE DISTRIBUTION ASTM D421 AND D422
US STANDARD SIEVE OPENING SIZES**



USCS	COBBLES	Coarse	Fine	Cor	Med	Fine	FINES (Silt and Clay)
		GRAVEL		SAND			

SAMPLE ID	W%	LL	PL	PI	Gs	DESCRIPTION
BOREHOLE SAMPLE NO. PC-22 DEPTH		27	15	12	2.68	Silty CLAY with some coarse to fine sand, trace coarse to fine gravel

Sample Type: Date Tested: OCT 1992 USCS: CL

TECH: MK
DATE: 11/09/92
CHECKED: KR
REVIEWED: DR

GCS/927-1203/MI
IC3-2048

FILENAME: D4PC22

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

D.2

DRAINAGE AGGREGATES

D.2.1
GRAVEL

JUNE 1993

917-1203

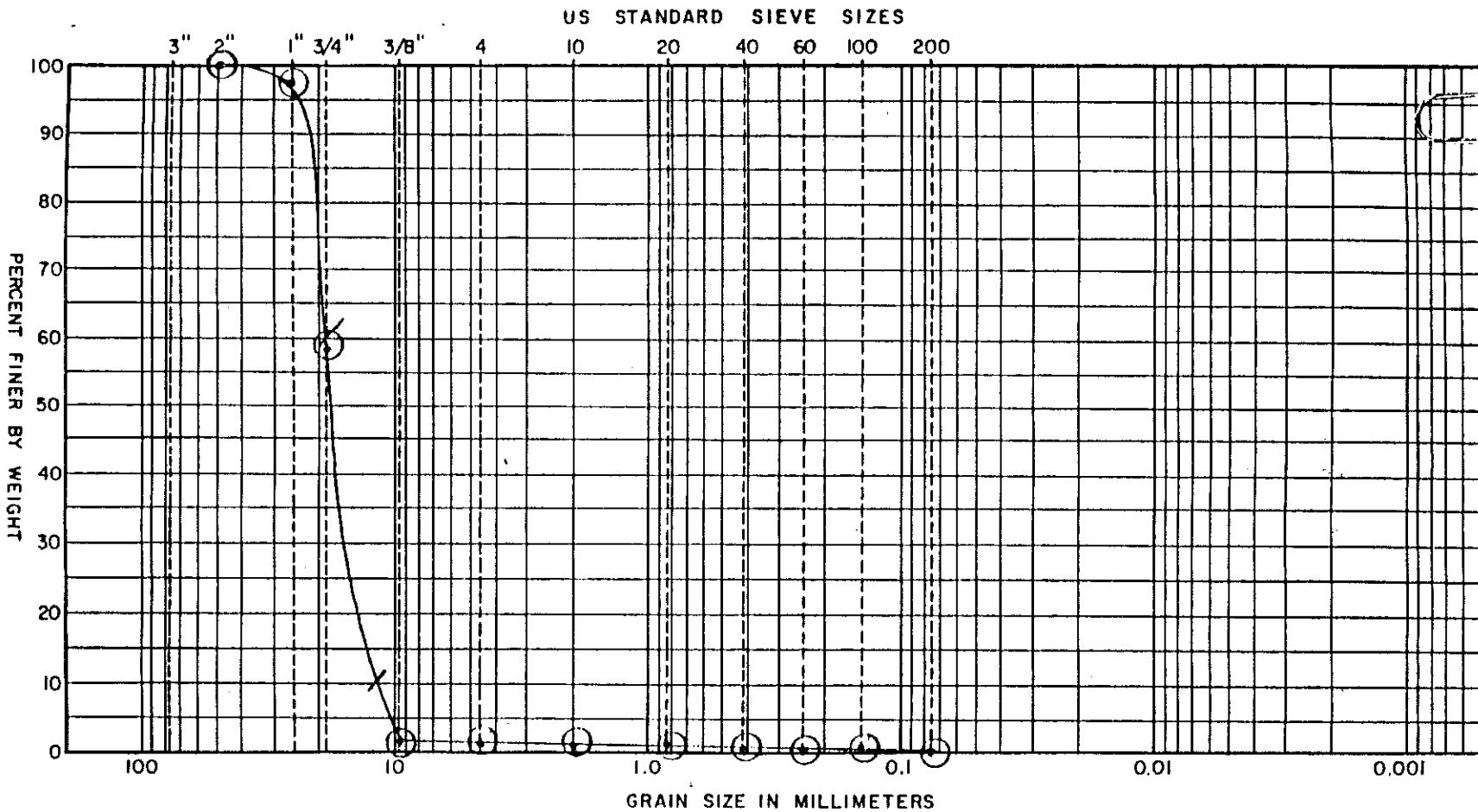
SUMMARY OF GRANULAR MATERIAL LABORATORY TEST RESULTS
ALLEN PARK CLAY MINE - CELL 2
FORD MOTOR CO.

SAMPLE NO.	NATURAL MOISTURE CONTENT (%)	DRY DENSITY (pcf)	WET DENSITY (pcf)	GRAIN SIZE ANALYSIS		HYDRAULIC CONDUCTIVITY (cm/s)	TEST BY
				% PASSING #4 SIEVE	% PASSING #200 SIEVE		
GRAVEL LAYER MATERIALS							
GA-1 (GP)	1.61	100.8	102.5	0.38	0.00	4.72	GAI
GA-2 (GP)	-	-	-	1.61	0.82	-	GAI

FILENAME = TBL-GRAV.WK1 disk 5

GRAIN SIZE DISTRIBUTION

FIGURE



COBBLES	GRAVEL		SAND			FINES	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO.	ELEV. OR DEPTH	w_n	w_L	w_p	I_p	DESCRIPTION OR CLASSIFICATION
GA-1	—	1.61	—	—	—	Tan, Brown, White, C-F GRAVEL, (rounded to subrounded), trace sand $D_{60}/D_{10} = 1.46 \Rightarrow (GP)$

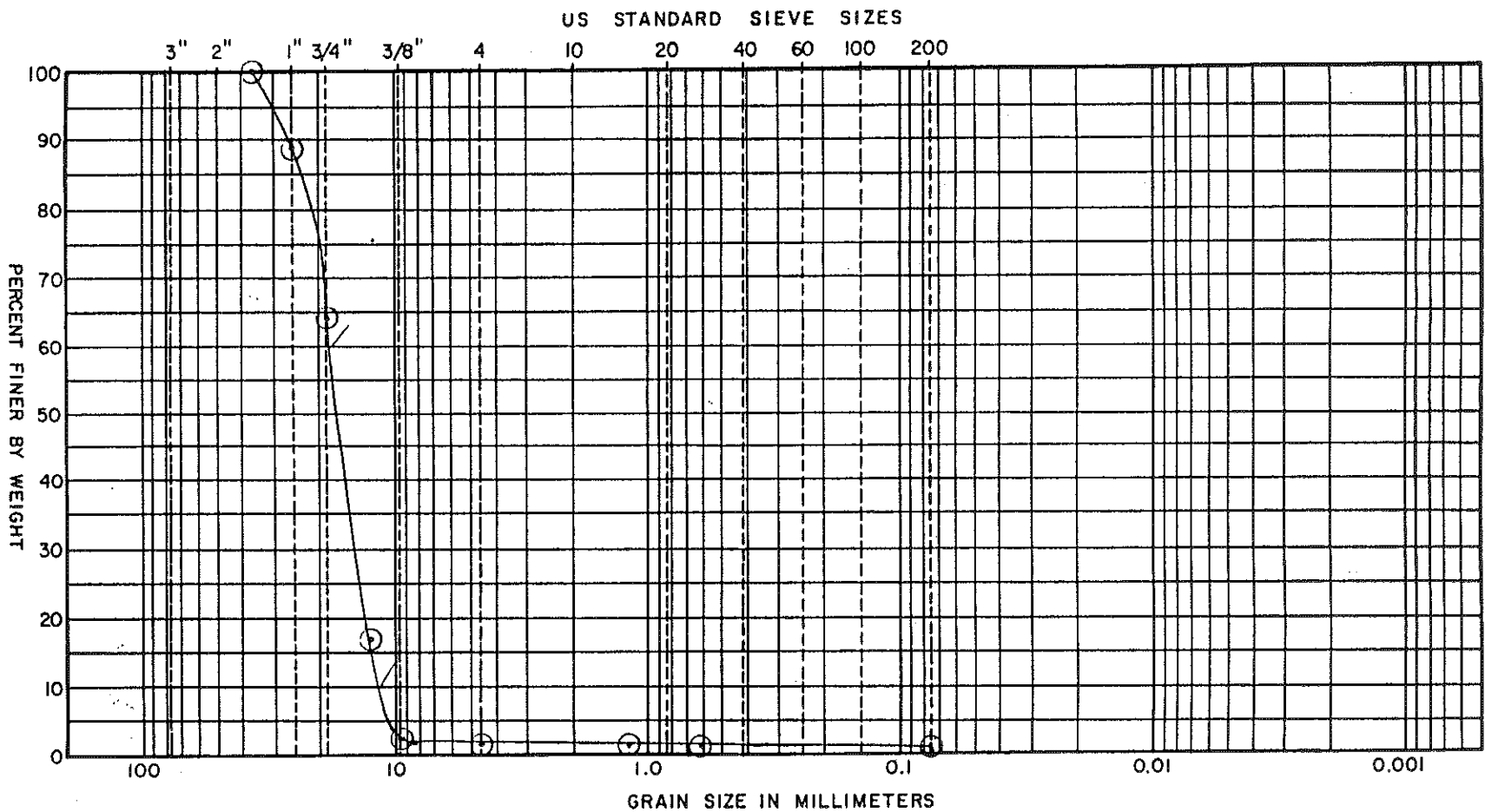
Date 6/23/12
Job No. 103-3908

Golder Associates

Drawn WMS
Checked WMS
Reviewed WMS

GRAIN SIZE DISTRIBUTION

FIGURE



COBBLES	GRAVEL		SAND			FINES	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO.	ELEV. OR DEPTH	W _n	W _L	W _p	I _p	DESCRIPTION OR CLASSIFICATION
Stockpile, GA-2						Grey, C-F GRAVEL, Trace sand. (GP) $C_u = \frac{14}{12} = 1.6$

Date 12/10/62
Job No. 103-3708

Golder Associates

Drawn for S
Checked by
Reviewed

D.2.2

SAND

JUNE 1993

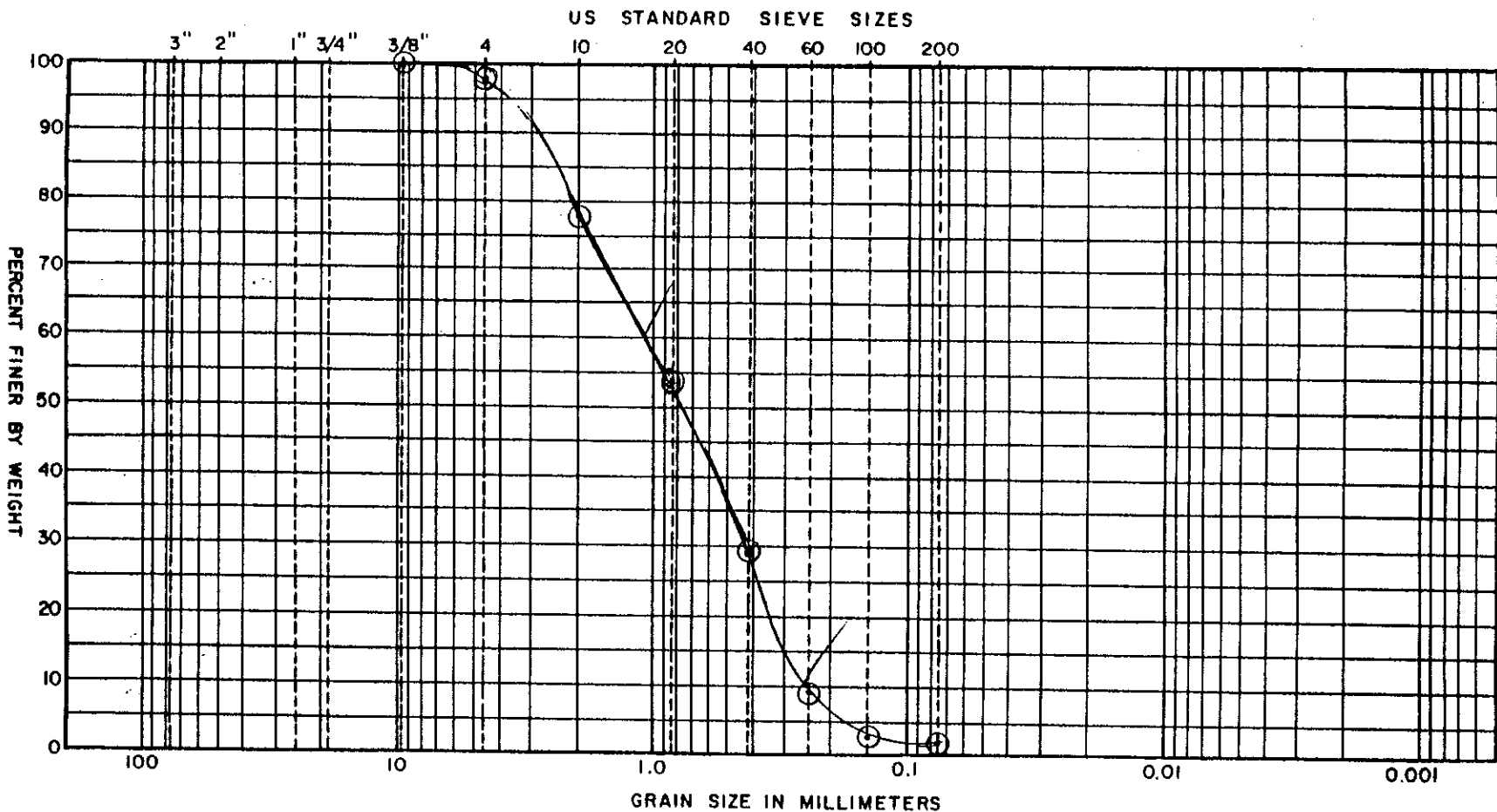
917-1203

SUMMARY OF GRANULAR MATERIAL LABORATORY TEST RESULTS
ALLEN PARK CLAY MINE - CELL 2
FORD MOTOR CO.

SAMPLE NO.	NATURAL MOISTURE CONTENT (%)	DRY DENSITY (pcf)	WET DENSITY (pcf)	GRAIN SIZE ANALYSIS		HYDRAULIC CONDUCTIVITY (cm/s)	TEST BY
				% PASSING #4 SIEVE	% PASSING #200 SIEVE		
GRANULAR SYSTEM OF LEACHATE COLLECTION/REMOVAL SYSTEM							
LB-2 (SP)	3.7	97.2	100.8	98.90	1.60	4.8E-02	GAI
LB-3 (SP)	4.1	100.0	104.0	99.25	2.03	4.4E-02	GAI
KENT LAKE 2NS	9.9	113.2	-	-	-	1.2E-02	SME

FILENAME = TBL-SAND.WK1 disk 5

GRAIN SIZE DISTRIBUTION



COBBLES	GRAVEL		SAND			FINES	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO.	ELEV. OR DEPTH	w_n	w_L	w_p	I_p	DESCRIPTION OR CLASSIFICATION
Kent Lake, LB-2						Tauuish Brown, C-F SAND, trace silt, $C_u = \frac{1.15}{.26} = 4.4$ trace f-gravel (SP)

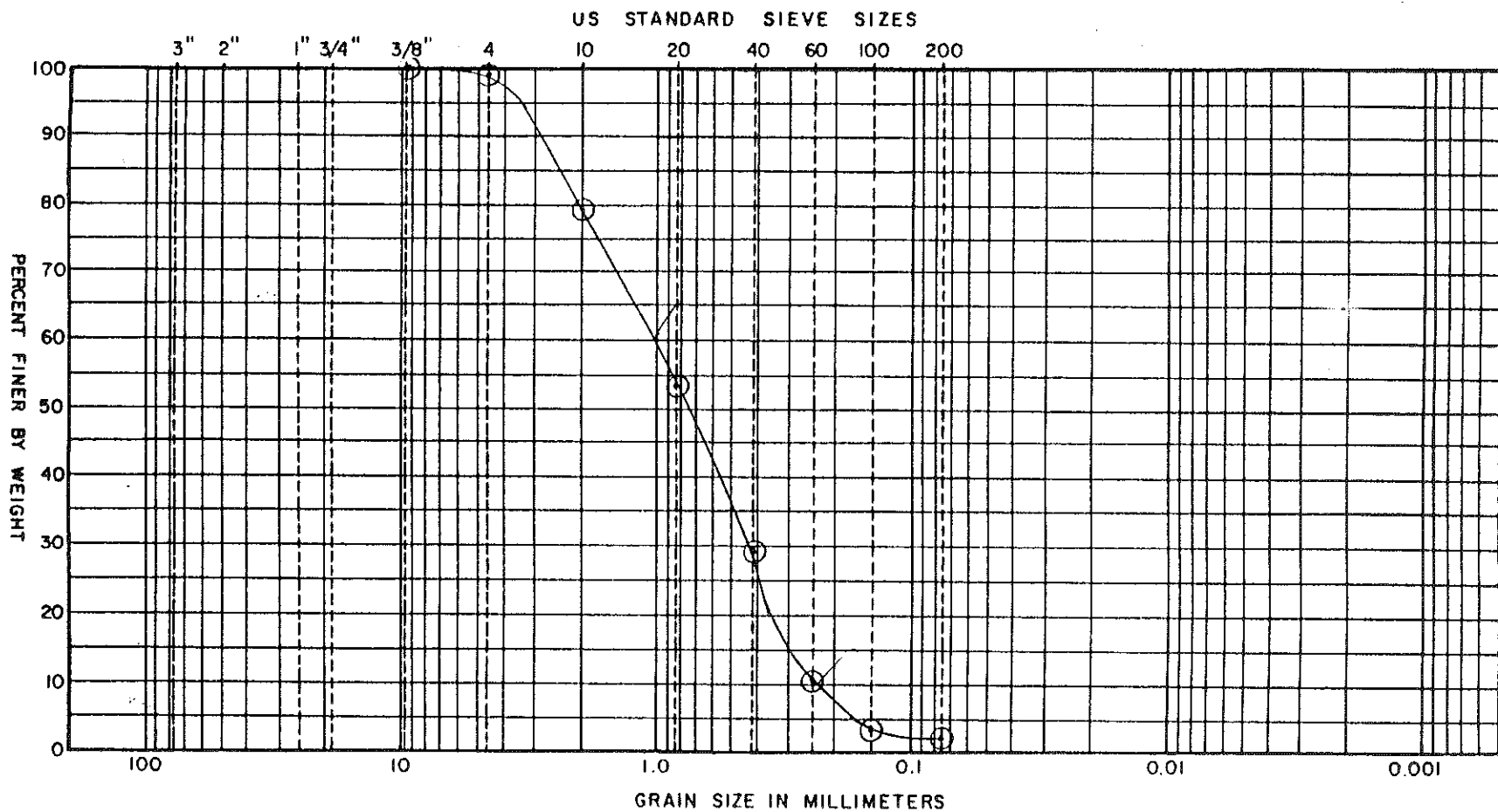
FIGURE

Date 10/7/92
Job No. 103-3708

Golder Associates

Drawn file
Checked file
Reviewed file

GRAIN SIZE DISTRIBUTION



COBBLES	GRAVEL		SAND			FINES	
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO.	ELEV. OR DEPTH	W _n	W _L	W _p	I _p	DESCRIPTION OR CLASSIFICATION
Stockpile, LB-3						Tan & Brown mix, C.F. SAND, trace silt (SP) $C_u = \frac{1.0}{.24} = 4.2 < 6$

FIGURE

Date 10/10/92
Job No. 103-3708

Golder Associates

Drawn SWB
Checked BBF
Reviewed _____

